Province of
British Columbia

Ministry of
Environment

WATER
MANAGEMENT
BRANCH

STORMWATER MONITORING OF A RESIDENTIAL CATCHMENT AREA

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June 1983

SUMMARY

A stormwater monitoring program was undertaken during 1981 by the Aquatic Studies Branch (now Resource Quality Section of the Water Management Branch). Stormwater originated from a 12.95 hectare residential catchment area in Vancouver. This work had been recommended by the Water Quality Work Group of the Phase I Fraser River Estuary Study, and subsequently was endorsed by the Pollution Control Board. This report details the findings of the monitoring program, and compares them to those predicted by the Water Quality Work Group. It also compares actual values to values for stormwater reported in the literature.

Precipitation volumes and quality were measured throughout the catchment area. About 37% more rainfall occurred than "normal" during this program, and rainfall was generally evenly distributed throughout the catchment area. Rainfall was generally acidic, with a median pH of 4.85. Concentrations of metals in precipitation were low throughout the catchment area, although lead values were consistently higher at one sampling site near a roadway.

Dustfall samples were collected throughout the catchment area and analyses were conducted on about a monthly basis. Dustfall values as expected were higher than for pristine areas, but lower than the range of values cited in the Pollution Control Board ambient air quality objectives. Lead concentrations were consistently higher at one sampling site near a roadway.

Loadings of certain constituents in stormwater were determined as being predominantly from precipitation or dustfall. It was found that precipitation contributed all the nitrogen loading in stormwater. Precipitation contributed more of the copper, lead, and zinc loadings to stormwater than did dustfall, but only 30% of the phosphorus loading. Chloride and sodium loadings resulted more from dustfall than from precipitation.

Soil surface moisture contents were measured about weekly. They were found to drop from about 34% in the December through June period to 27% during the July through September period, due to lack of rainfall. The mean runoff coefficient throughout the study was 0.40, which compares to a value of 0.45 assumed by the Water Quality Work Group. This value decreased for precipitation events during July and August, when the highest recorded value was 0.35.

Two prepared columns of undisturbed soil indicated that infiltration and runoff rates would vary throughout the catchment area, depending upon the soil composition at any site.

Recorded stormwater flows extrapolated to all residential land in the Fraser River study area were 45% higher than predicted by the Water Quality Work Group for a "normal" year. However rainfall was 37% higher than "normal" during the study period of 1981.

A multiple linear regression indicated that for four input variables, the runoff coefficient varied predominantly with average storm duration, and to a lesser extent with maximum hourly rainfall and average storm intensity. The number of antecedent dry days had little effect on the runoff coefficient.

Values for several constituents in stormwater varied with flow. These included coliforms, aluminum, copper, lead, and zinc. The pH of stormwater decreased during wet weather flows, likely due to the acidic nature of the precipitation and the short contact time between the soil and rainwater.

Stormwater runoff from the residential catchment area was found to be non-acutely toxic to rainbow trout, although it was acutely toxic to Daphnia magna.

Pesticides and polychlorinated biphenyls could not be detected in stormwater when tested, although PCB's were present in grit accumulated by stormwater.

Concentrations of total aluminum, copper, lead and zinc in stormwater increased with increased wet weather flows, resulting in large metal loadings. Values of lead in stormwater were about the same as those recorded in rainfall.

Recorded values for some constituents were less than reported in the literature for other stormwater studies. These included BOD_5, suspended solids, TOC, fecal coliform, cadmium, chromium, copper, lead, nickel, zinc, total phosphorus, ammonia, nitrate/nitrite and total Kjeldahl nitrogen. Constituents with recorded values higher than in the Fraser River within the Fraser River Estuary Study area included copper, ammonia, nitrate/nitrite, organic nitrogen, mercury and zinc. Coliform values in stormwater were higher than values in chlorinated effluent from the Annacis STP.

Analyses of sediments associated with stormwater indicated that lead and zinc concentrations were higher than average sediment levels in the Fraser River. This could indicate that lead and zinc are the only metals contributed in any significant amounts by stormwater.

Values recorded in stormwater compared to the effluent quality from the Annacis STP showed that the mean value for lead was the only one which exceeded the mean value in the primary treated sewage. In fact, it was about twice the value.

Extrapolating stormwater loadings to all residential areas within the Fraser River Estuary Study area indicated that suspended solids, COD, aluminum, copper, lead and zinc during the first hour of a storm would be higher in stormwater than the average loads from the three main sewage treatment plants. When a peaking factor was applied to the loads from the municipal plants, loads of copper, lead, and zinc in stormwater would still be higher. In terms of average daily loadings, loadings of lead from stormwater and sewage treatment plant effluents were about equal, while stormwater loadings of zinc were about one-half and copper about one-third the loadings from the sewage treatment plants.

A "first flush" of lead and zinc appeared in 75% of storms, of COD in 67% of storms and of aluminum in 50% of storms.

Stormwater is in all likelihood one of the major sources of high lead and zinc values in the sediments and the water column of the North Arm of the Fraser River. There are 44 storm drains entering the North Arm of the Fraser River as well as an additional 13 combined sewer overflows. Stormwater is an integral portion of combined sewage.

Any attempt to treat stormwater, by providing storage for the "first flush" of a storm, will require storage volumes in excess of 150 000 m^3. This storage requirement is over 10% of the total daily design of the three main sewage treatment plants. The implementation of any storage scheme will require that existing treatment capacities at the sewage treatment plants be examined.

TABLE OF CONTENTS

Page

SUMMARY i

TABLE OF CONTENTS v

LIST OF FIGURES ix

LIST OF TABLES x

ACKNOWLEDGEMENTS xiii

PART I: THE SETTING 1

1.0 INTRODUCTION 1

- 1.1 Preamble 1
- 1.2 Review of Fraser River Estuary Study, Water Quality, Stormwater Discharges 1
  - 1.2.1 General 3
  - 1.2.2 Loadings Contributed by Stormwater 4

2.0 LITERATURE REVIEW 6

- 2.1 Introduction 6
- 2.2 "First Flush" 7
- 2.3 Atmospheric Dust 8
- 2.4 Quality of Rainfall 9
- 2.5 Quantities of Contaminants in Runoff 10
- 2.6 Treatment of Stormwater 11
- 2.7 Computer Models 13

3.0 VANCOUVER RESIDENTIAL STORMWATER MONITORING SITE-1980-1981 14

- 3.1 Site Description 14
- 3.2 Monitoring Program 18
  - 3.2.1 Stormwater Measurements 18
  - 3.2.2 Precipitation and Air Quality Sampling 19
  - 3.2.3 Infiltration and Runoff Monitoring 20

TABLE OF CONTENTS (Continued)

Page

PART II: PRESENTATION OF RESULTS 22

4.0 PRECIPITATION 22

4.1 Quantity 22
4.2 Quality 24

4.2.1 pH.. 25
4.2.2 Acidity.. 25
4.2.3 Ions.. 26

4.2.3.1 Calcium 26
4.2.3.2 Chloride 26
4.2.3.3 Magnesium 26
4.2.3.4 Potassium 27
4.2.3.5 Phosphate 27
4.2.3.6 Sodium 27
4.2.3.7 Sulfate 27

4.2.4 Heavy Metals.. 27
4.2.5 Nitrogen.. 28

4.2.5.1 Ammonium Nitrogen 28
4.2.5.2 Nitrate Nitrogen 29
4.2.5.3 Nitrite Nitrogen 29

4.3 Discussion 29

5.0 AIR QUALITY 32

5.1 Soluble Components 32

5.1.1 Chloride 32
5.1.2 Fluoride 32
5.1.3 Sodium 32

5.2 Metals 33

5.2.1 Arsenic 33
5.2.2 Cadmium 33
5.2.3 Copper 33
5.2.4 Lead 34
5.2.5 Mercury 34
5.2.6 Zinc 34

5.3 Particulate Matter 35

5.3.1 Total 35
5.3.2 Soluble 36
5.3.3 Insoluble 36

TABLE OF CONTENTS (Continued)

Page

5.4 Discussion 36

6.0 INFILTRATION AND RUNOFF 38
  6.1 Soil Moisture Content 38
  6.2 Infiltration 40

7.0 STORMWATER RUNOFF 42
  7.1 Quantity 42
  7.2 Quality 45
    7.2.1 Bacteriological Data 52
    7.2.2 Carbon 53
    7.2.3 Metals 54
      7.2.3.1 Aluminum 54
      7.2.3.2 Cadmium 55
      7.2.3.3 Chromium 55
      7.2.3.4 Copper 56
      7.2.3.5 Iron 57
      7.2.3.6 Lead 57
      7.2.3.7 Manganese 58
      7.2.3.8 Mercury 59
      7.2.3.9 Molybdenum 59
      7.2.3.10 Nickel 59
      7.2.3.11 Zinc 59
    7.2.4 Nitrogen 61
      7.2.4.1 Ammonia Nitrogen 61
      7.2.4.2 Kjeldahl Nitrogen 62
      7.2.4.3 Nitrate/Nitrite Nitrogen 62
      7.2.4.4 Total Nitrogen 63
    7.2.5 Oil and Grease 63
    7.2.6 Oxygen Demanding Substances 64
    7.2.7 pH 65
    7.2.8 Pesticides 66
    7.2.9 Arsenic 66
    7.2.10 Phenolics 66
    7.2.11 Phosphorus 67
    7.2.12 Polychlorinated Biphenyls 68
    7.2.13 Solids 68

TABLE OF CONTENTS (Continued)

Page

7.2.13.1 Specific Conductance 68
7.2.13.2 Suspended Solids 68
7.2.13.3 Grit and Sediment 70

7.2.14 Toxicity 72

7.3.14.1 Fish Bioassays 72
7.2.14.2 *Daphnia* Bioassays 73

7.3 Summary of Conclusions 74

PART III: INTERPRETATION OF RESULTS 77

8.0 DISCUSSION 77
8.1 Stormwater Contaminant Concentrations 77
8.1.1 Variations in Concentrations 77
8.1.2 Comparison with Municipal Sewage 78

8.2 Stormwater Loadings 78

8.2.1 Sources of Loadings 79
8.2.2 First Hour Loadings 80
8.2.3 First Flush 81
8.2.4 Impact on Receiving Waters 82

8.3 Treatment of Stormwater 83

9.0 CONCLUSIONS 85

9.1 Rainfall 85
9.2 Dustfall Quality 85
9.3 Infiltration and Runoff 85
9.4 Stormwater Runoff Quality 86

10.0 RECOMMENDATIONS 90

REFERENCES 91

APPENDIX I 221

APPENDIX II 222

LIST OF FIGURES

Page

1. Location of Catchment Area 2

2. Rupert Street Study Area 15

3. Rupert Street Study Area, Stormwater Collection System 16

4. Surface Soil Mean Moisture Contents from December 1980 through November 1981 39

5. Runoff Coefficient as a Function of Antecedent Dry Days, Average Intensity, Maximum Hourly Rainfall, and Storm Duration 44

6. Fluctuations in Concentrations of Selected Parameters in Stormwater Runoff from the First Three Hours of a Large Storm Event 46

7. Fluctuations in Concentrations of Selected Parameters in Stormwater Runoff for an Entire Storm 49

LIST OF TABLES

Page

1. 1980-1981 Precipitation Records, Rainfall Gauge Rosemont and Kerr . 95

2. Precipitation Collectors 108

3. Monthly Precipitation Records - Vancouver International Airport .. 111

4a. Rainfall Quality Data, Comparison of Three Sites on a Sample Basis 112

4b. Summary of Precipitation Data at Three Sites 140

4c. Precipitation Quality of Other Selected British Columbia Locations.141

5a. Dustfall Quality Data, Comparison of Three Sites on a Sample Basis.142

5b. Summary of Dustfall Data at Three Sites 152

6. Measured Surface Soil Moisture Content 153

7. Measured Runoff and Infiltration 155

8. Total Daily Stormwater Flows 163

9. Runoff Coefficients 164

10. Dry Weather Stormwater Quality 168

11. Wet Weather Stormwater Quality 170

12. Dry Weather Stormwater Loadings 172

LIST OF TABLES (Continued)

Page

13. Wet Weather Stormwater Loadings 174

14. Bioassay Data Summary (Rainbow Trout) 184

15. _Daphnia_ Bioassay Data Summary 186

16. Trace Metal Analyses for Effluent Used In _Daphnia_ Bioassay 187

17. Analysis of Accumulated Grit and Sediment Deposited in the Flume . 188

18. Metal Values in the Suspended Fraction 189

19. Reported Concentrations of Parameters for two Australian Residential-type Catchment areas 191

20. Trends of Concentrations Throughout Individual Storms 192

21. Factors Affecting Runoff Coefficients 199

22. Comparison of Mean Stormwater Concentrations and Mean Municipal Sewage Treatment Plant Concentrations 203

23. First Hour Loadings From All Catchment Areas 204

24. Contaminant Loadings From Rupert and Rosemont Extrapolated to All Residential Areas in the Fraser River Estuary Study Area 205

25. Determination of First Flush Events 206

26. Relationship of Loadings From Precipitation and Loadings from Dry Deposition as measured at the Stormwater Outfall 214

27. Stormwater Loadings and Their Origin 215

LIST OF TABLES (Continued)

Page

28. Comparison of Stormwater Loadings With Those From Sewage Treatment Plants 216

29. Statistical Evaluation of Variability of Precipitation Quality Measurements Between Sites 217

30. Statistical Evaluation of Variability of Dustfall Quality Between Sites 219

ACKNOWLEDGEMENTS

The stormwater monitoring programme undertaken by Aquatic Studies Branch (now Resource Quality Section of Water Management Branch) personnel required input from many agencies and individuals. The Engineering Departments of Burnaby, New Westminster, and Surrey provided valuable input in the planning stage. Mr. John Atwood of the City of Vancouver Engineering Department was an essential link between the Water Management Branch and all staff members of the City of Vancouver Engineering Department in site selection and sampling strategies.

Dr. Malcolm Clark of the Waste Management Branch generously provided automatic samplers, linear strip chart recorders, and other equipment. Mr. D. Pengally and his staff at the Environmental Laboratory were essential in maintaining the equipment in an operational mode. Mr. Ron Watts and his staff at the Environmental Protection Service of Environment Canada provided office facilities as well as fish bioassay tests. Mr. Bruce Anderson of the University of British Columbia performed the bioassay test on *Daphnia*, and Mr. N. Nagpal of the Terrestrial Studies Branch designed and prepared soil columns for runoff and infiltration measurements. Mr. B. Bevan of the Air Studies Branch provided the raingauge and kept it in good repair.

Especially important in any successful monitoring programme is the devotion of technicians who operate above and beyond minimum requirements. In this regard we are especially grateful to Mr. Bruce Holms who spent many sleepless nights and long days collecting the data presented herein and maintaining the site. Mr. Holms was also responsible for performing the statistical calculations presented herein, as well as preparing Appendix II.

To these people we express our sincere thanks.

PART I: THE SETTING

1.0 INTRODUCTION

1.1 PREAMBLE

The Summary Report of the Water Quality Work Group for the Fraser River Estuary Study recommended a one-year study programme "to characterize stormwater, and to estimate more accurately its contribution to contaminant loadings to the river. At least three catchment areas would be selected, which are typical of industrial, commercial, and residential districts in the area" (1). Calculations and extrapolations indicated that the effect of stormwater on water quality and aquatic biota may be as important as that of municipal sewage.

However, predictions on the effects of stormwater pollution were based upon calculations which utilized literature derived values. No actual field measurements of flow and stormwater quality had ever been made in a systematic manner.

In November 1980, the Aquatic Studies Branch (now Resource Quality Section of the Water Management Branch), Ministry of Environment commenced a one year study programme at a stormwater outfall in Vancouver (see Figure 1), which drained a typical "middle-class" residential area, approximately 13 hectares in size. This programme was to be the most intensive systematic study of stormwater pollution ever carried out within British Columbia.

1.2 REVIEW OF FRASER RIVER ESTUARY STUDY, WATER QUALITY, STORMWATER DISCHARGES(3)

The basis for the recommendations in the Summary Report was work carried out in a background report, prepared by Ferguson and Hall(3). The following summarizes some of the more important findings of the Ferguson and Hall report.

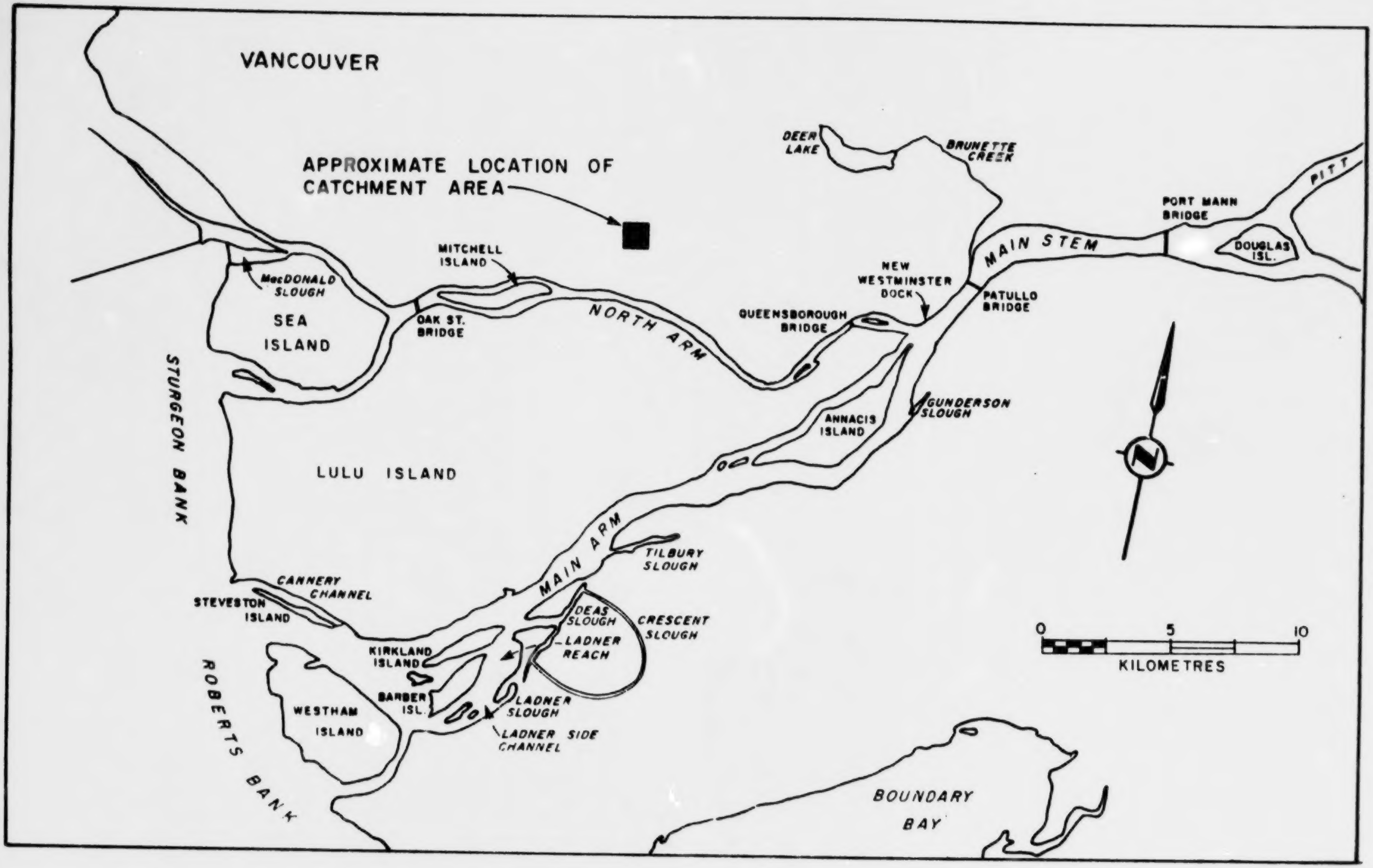

VANCOUVER
APPROXIMATE LOCATION OF CATCHMENT AREA
DEER LAKE
BRUNETTE CREEK
PORT MANN BRIDGE
PITT
DOUGLAS ISL.
MAIN STEM
MITCHELL ISLAND
MacDONALD SLOUGH
SEA ISLAND
OAK ST. BRIDGE
NORTH ARM
NEW WESTMINSTER DOCK
PATULLO BRIDGE
QUEENSBOROUGH BRIDGE
STURGEON BANK
GUNDERSON SLOUGH
ANNACIS ISLAND
LULU ISLAND
MAIN ARM
TILBURY SLOUGH
CANNERY CHANNEL
STEVESTON ISLAND
DEAS SLOUGH
CRESCENT SLOUGH
LADNER REACH
KIRKLAND ISLAND
ROBERTS BANK
BARBER ISL.
LADNER SLOUGH
LADNER SIDE CHANNEL
WESTHAM ISLAND
0
5
10
KILOMETRES
BOUNDARY BAY

FIGURE 1 . LOCATION OF CATCHMENT AREA

1.2.1 GENERAL

Ferguson and Hall reviewed previous studies in the Greater Vancouver Regional District (GVRD), as well as other pertinent literature. Three reports dealing with the GVRD were of particular importance; one being a Westwater Research Centre report on work carried out during 1973-1974 on the Brunette River and Still Creek; the second being a 1973 brief submitted by the Greater Vancouver Sewerage and Drainage District (GVS & DD) to a public enquiry on municipal waste disposal; and the third being a report by M.A. Franson (4)(5)(6)(7).

The report on the 1973-1974 Brunette River - Still Creek study indicated that at most sampling stations, copper, lead, and zinc increased during high stormwater flows. Manganese concentrations increased during low flows and were thought to originate with groundwater (4)(5).

The GVS & DD calculated stormwater pollutant loadings based upon an EPA report which indicated that the runoff from the first hour of a moderate-to-heavy storm would contribute more pollutants than would the city's sanitary system during the same period of time(3).

Ferguson and Hall felt that calculated stormwater pollutant loadings in the Franson report were not accurate(3). However, they did go on to quote Franson, who concluded that "pollutant loadings from stormwater, domestic sewage, and industrial effluents were of a similar order of magnitude and, therefore, concentration on control of any one aspect to the exclusion of others would lead to only comparatively minor gains in the reduction of pollution to the region's receiving waters"(3).

The literature review undertaken in Ferguson and Hall's report indicated that reported stormwater pollutant concentrations vary greatly for a number of reasons. For example, higher pollutant concentrations may be expected in the early stages of a storm (first flush), in highly paved or industrialized areas, in response to intense rainfall periods, after prolonged dry periods, and in areas with construction activities. Ferguson and Hall referenced one study in Tulsa, Oklahoma which found that the greatest variation in quality occurred for suspended solids and bacteriological parameters. A second study found that from 75% to over 95% of the total amount of street surface contaminants was removed during the first hour of rainfall.

In addition, Ferguson and Hall stated that "typical stormwater is often characterized as having an equal to or greater NFR concentration than untreated sanitary wastewater and a BOD_5 equal to that of secondary treated effluent"(3). (NFR is an abbreviation used by Ferguson and Hall to represent non-filterable residue, or suspended solids).

1.2.2 LOADINGS CONTRIBUTED BY STORMWATER

Franson used concentrations of 40 mg/L for five-day biochemical oxygen demand (BOD_5) and 250 mg/L for suspended solids to estimate stormwater loadings during each of the years 1973, 1986, and 2000. Associated with each of these years were runoff coefficients of 0.4, 0.45, and 0.5, respectively. These coefficients allowed for increases in the urbanized land area from 30 500 hectares in 1973 to 38 500 hectares in 1986 and 47 600 hectares in the year 2000(3).

Ferguson and Hall attempted a more refined approach than Franson in determining stormwater loadings by considering some of the physical aspects of the drainage area to the Fraser River. They calculated the quantity of urban runoff using the proportion of five land use groups in each municipality of the drainage area, average annual precipitation over each municipality, and runoff coefficients for each land use group. Average stormwater pollutant concentrations for each land use as reported in the literature were also used.

For residential land use, applicable to our study, Ferguson and Hall used a runoff coefficient of 0.45, and the following concentrations: BOD_5, 29 mg/L; total nitrogen, 2 mg/L; total phosphorus, 0.6 mg/L; total coliform, 100 000 MPN/100 mL; fecal coliform, 11 000 MPN/100 mL; copper, 0.01 mg/L; iron, 0.255 mg/L; manganese, 0.023 mg/L; nickel, 0.002 mg/L; lead, 0.06 mg/L; and zinc, 0.008 mg/L. They did not indicate whether these metals were expressed as "total" or "dissolved".

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

The impact of stormwater on the quality of receiving streams can be serious. This impact can be lethal or sub-lethal to aquatic life, the former being easier to detect. Heaney *et al*. (1981) reviewed over 10 000 reported fish kills in the United States in the period from 1970 to 1979 and found that nearly 3% of these attributed urban runoff as the direct cause(8).

Oxidation processes can reduce oxygen levels to such a degree that they affect the survival of fish. Suspended solids can increase turbidity and thereby reduce light penetration and algal production. They can clog and cloud fish gills, can cause aesthetic nuisance, and in addition, the settleable fraction can be deposited so as to destroy habitat for fish or bottom dwelling organisms. The organic settleable solids can also be a reservoir of oxygen demanding substances, bacteria, metals, nutrients, and organic chemicals. Nutrients can, in certain situations such as lakes, lead to eutrophication. Bacteria and viruses can pose a health hazard to man and aquatic organisms. Heavy metals can cause toxic conditions for aquatic life, as well as concentrate in the food chain.

Urban drainage is a significant source of pollution(9). With rainfall, contaminants are dislodged and become suspended. This runoff carries these contaminants in gutters and storm sewers, eventually to be discharged to receiving waters. These contaminants can contribute both shock loads and background pollution to receiving waters(9). The amount and composition of these contaminants can vary with the day of the week, the season, land use, population density, and pedestrian and vehicular traffic(9).

In general, pollutants in stormwater originate from raindrops contacting pollutants in the air, from rainwater passing over surfaces, or from the runoff conveyance system. These pollutants include oxygen demanding substances, solids, nutrients, bacteria, heavy metals, pesticides, and oil and grease(10). "The rapid transfer of increased rates and volumes of runoff from urban development has increased the likelihood of drainage related problems in receiving streams, i.e., flooding, bed and bank erosion, and sedimentation"(9). This rapid transfer, caused by the increased imperviousness of an area, can also lead to groundwater depletion and reduced dry-weather stream flows.

The runoff can vary according to the slope of land, soil types (which have varying permeability coefficients), amount of impervious surfaces, rainfall intensities, and degree of saturation. The degree of saturation is affected by the antecedent rainfall which can saturate the soil and fill surface depression storage. In cases where the antecedent rainfall is heavy, a subsequent light rainfall can generate as much runoff as a heavy rainstorm which has been preceded by a long dry period(11).

2.2 "FIRST FLUSH"

In addition to being an important factor in determining the runoff coefficient, the number of antecedent dry days will likely affect the quantity of pollutants which have accumulated since the previous storm event. It has been indicated that long periods without precipitation can result in little increase in the initial concentration of pollutants(12). Other studies have indicated that the opposite can occur(13). Gore and Storrie Ltd. defined the antecedent dry days as the "number of days preceding a storm during which the total accumulated rainfall was less than one inch" (25 mm)(14).

Helsel et al. (1979) cited the work of Colston who described a "first flush" effect in stormwater as being "an initially high pollutant concentration followed by decreasing concentrations as the storm proceeds"(15). This "first flush" effect is a function of the antecedent dry weather flow, the conveyance system geometry, and the actual rainfall event. The average incidence of "first flush" increases with urbanization(15).

Helsel et al. also reported that extractable metals measured at commercial sites showed a "first flush" effect, based upon concentrations, an average of 90% of the time. High-rise and other residential sub-basins indicated an extractable metal first flush in an average of 80% of all storms. The agricultural sites averaged 64%, and the forested site 0% for all storms. For soluble metals, the averages were lower than extractable metals(15).

The use of concentrations to define "first flush" is not always reliable, since concentrations are flow dependent. In order to reflect loadings in the "first flush" phenomenon, Helsel et al. noted that Griffin defined "first flush" quantitatively in terms of loads(15). Griffin plotted the flow and total storm load against the percentage of time elapsed during the storm, and defined "first flush" as the period when the ratio of incremental load to total load exceeds the ratio of incremental flow to total flow (incremental load ratio/incremental flow ratio >1.0) during any time period.

2.3 ATMOSPHERIC DUST

Particulate matter which settles as atmospheric dustfall, or when suspended is washed out of the air by precipitation, results from natural and anthropogenic sources. It can be washed off surfaces during rainfall events. Contaminant removal during rainfall is a direct function of the amount of rainfall(16). The same percentage of contaminants can be removed from surfaces with equal quantities of rainfall, regardless of the rainfall intensity(16). A removal efficiency of 90% can be attained with a rainfall of about 13 mm(16).

Street sweeping is one method of removing atmospheric dust, a topic addressed extensively in Ferguson and Hall(3). However, street sweeping has an overall removal effectiveness of only about 50 percent(16).

2.4 QUALITY OF RAINFALL

There are many major problems associated with characterizing the chemical composition of precipitation. These include:

1. The requirement to obtain a representative sample and reproducible chemical analyses.
2. Changes which occur within the sample, once collected, due to the presence of foreign particles such as leaves.
3. The effect on chemical composition of storage, including the collection time, prior to laboratory analysis.
4. Interaction of rain with collector surfaces.
5. The effects of the sampling interval.

It has been found that in general, samples from small rainfall events have higher concentrations of scavenged gases and particulates than from large events. As well, precipitation during the early part of a large storm contains higher concentrations of scavenged materials than precipitation during latter parts of the storm.

Precipitation contains several substances, including ions, heavy metals, and other acidifying substances. Some substances in precipitation occur naturally, such as chloride which originates mainly from the ocean. Other substances are anthropogenic. Nitrate in precipitation is due in large part from emissions of nitrogen oxides from various industries, high temperature engines, and oil-based power plants. Ammonium ion indirectly originates from soils, where man has applied fertilizers, or from eutrophied surface waters(40).

The major anions in precipitation are HCO_3^-, NO_3^-, Cl^-, and SO_4^{2-}. The major cations are H^+, Ca^{2+}, Mg^{2+}, Na^+, K^+, and NH_4^+. Acids are formed due to chemical and photochemical reactions involving SO_2, H_2S, NOx, Cl^-, and NH_4^+. Strong acids are highly ionized.

2.5 QUANTITIES OF CONTAMINANTS IN RUNOFF

The quantity of a particular contaminant in runoff will depend upon several factors including land activities, antecedent conditions, precipitation characteristics, street cleaning practices, etc.(17). Earlier data on runoff reported for the United States indicated BOD_5 values could be 19 mg/L; COD, 99 mg/L; suspended solids, 210 mg/L; total phosphorus, 0.8 mg/L; and total nitrogen, 2.7 mg/L(13).

Ontario has adopted certain typical values for contamin-ants from residential areas. These values include a mean value for BOD_5 of 14 mg/L, based upon a range of values from 10.2 to 20.5 mg/L; a mean value for suspended solids of 170 mg/L, based upon a range of values from 77 to 305 mg/L; a mean value for total nitrogen of 3.5 mg/L, based upon a range of values from 1.3 to 4.12 mg/L; and a mean value of 0.35 mg/L for total phosphorus, based upon a range of values from 0.14 to 0.46 mg/L(18).

These mean values can be compared to other Ontario values for raw sewage of 165 mg/L BOD_5, 225 mg/L suspended solids, 30 mg/L total nitrogen and 6.5 mg/L total phosphorus. For primary treated sewage, values were 50). mg/L BOD_5, 50 mg/L suspended solids, 22 mg/L total nitrogen and 1.0 mg/L total phos- phorus. For secondary treated sewage, values were 17 mg/L BOD_5, 23 mg/L suspended solids, 18 mg/L total nitrogen and 1.0 mg/L total phosphorus(19

It has been indicated that lead concentrations in surface runoff can be about 200 times more than in secondary treated sanitary sewage(19). Some studies have indicated that heavy metal concentrations in stormwater would be 10 to 100 times greater than in sanitary sewage(16). Coliform values can be low in comparison to untreated sewage but can still exceed recreational water bacteriological standards(19).

A recent Australian publication has reported data from several types of catchments(48). Data for two residential type catchments have been combined and are reported in Table 19. The metal values cited therein are generally more similar to the concentrations found in sanitary sewage, except for lead and possibly zinc.

Several authors cited the fact that BOD_5 measurements may not be suitable for providing estimates of the oxygen demanding potential of stormwaters, and that the COD test may provide better estimates(16)(17)(20). Large amounts of heavy metals can interfere with BOD_5 measurements(16). Large quantities of organic material cannot be utilized by microorganisms in the BOD_5 test because significant quantities of toxicants in stormwater may have an inhibitory effect on BOD_5 values(20). This is verified by the fact that "copper, cadmium, lead and zinc contained in street runoff were found to be sufficiently soluble to cause toxic effects to certain aquatic organisms under selected conditions (such as soft water)"(16).

2.6 TREATMENT OF STORMWATER

Stormwater is more difficult to treat than sanitary sewage for two major reasons. These are:

(1) the intermittent and random occurrence of the runoff event with correspondingly high flow rates, and
(2) heavy loadings of solids(16).

The general consensus is that storage reservoirs alone or in conjunction with a sewage treatment plant are the most cost-effective method for managing urban runoff(16)(21). The construction of stormwater overflow tanks at sewage treatment plants, which permit treatment of all of the stored flows, is common in Europe(22).

The impoundment of stormwater is also common practice in Winnipeg, Canada. Studies on two such impoundments revealed that pollution loadings were reduced by 85% to 94% for suspended solids; 21% to 50% for total organic carbon; 30% to 75% for BOD_5; 22% to 26% for total Kjeldahl nitrogen; 71% to 83% for nitrate; 51% to 60% for total phosphorus; and 80% to 89% for lead(23). These reductions would vary, depending upon the design surface area and overflow rates. The average turn-over rates, based upon 410 mm of rainfall ranged from 0.73 to 1.2 times per year(41). These long residence times resulted because the primary consideration in their design was not stormwater treatment, but reducing pipe sizes and providing aesthetic surroundings.

Twelve hours retention provided at Barrhaven, Ontario removed 90% of suspended solids, 75% to 90% of bacteria, 20% to 50% of total phosphorus and organic nitrogen; but only marginal quantities of nitrate and BOD_5(11). In view of the 90% suspended solids removal but limited BOD_5 removal, the previously cited applicability of the COD test to measure the oxygen demanding potential may be a valid consideration in looking at these data.

Considerations which should be applied in the design of impoundments include:

(1) fountains for the aeration of impounded water,
(2) storage for at least twelve hours settling,
(3) discharge of settled runoff within 48 hours, with the fill and empty cycle taking a maximum of four days,

(4) discharge of runoff from the impoundment through a conduit to prevent recontamination at high discharge rates, and

(5) maintenance of a shallow pond (0.3 to 0.5 metre depth) for the prevention of scouring by dry weather flows(11)(23).

The volume of water to be treated will obviously determine the storage requirements and the ultimate cost of any impoundment. Assuming a "first flush" exists, the decision that only the "first flush" of a storm should be impounded can have a significant effect on cost. "Control costs are about one third less if a "first flush" is assumed"(24).

2.7 COMPUTER MODELS

Urban runoff computer models have been developed with the capability of simulating the quantity and quality of stormwater flows. Several computer models are available for each of these aspects, but perhaps the best documented one-event simulation model is the United States Environmental Protection Agency Storm Water Management Model (SWMM)(25).

It has been reported that for catchment areas ranging from 20 to 900 hectares predictions made by the SWMM model were within ± 20 percent of actual flows for about two-thirds of measured peak flows(25). However, a "comprehensive review of quality modelling and available field data showed that the simulation of the quality of stormwater was not as accurate as flow simulations"(25).

3.0 VANCOUVER RESIDENTIAL STORMWATER MONITORING SITE - 1980-1981

3.1 SITE DESCRIPTION

The stormwater outfall selected drained a 12.95 hectare residential catchment area in Vancouver (see Figure 2). The stormwater outfall was located at the foot of Rupert Street, adjacent to the Fraserview Golf Course. Stormwater from the catchment area, after draining through the outfall, entered a natural creek system which lead to the North Arm of the Fraser River.

The catchment area was made up mostly of single family dwellings, although a townhouse complex existed along the catchment area's northern boundary. The area was generally grass covered, with paved sidewalks and roadways. Some rock retaining walls were utilized throughout the area, and several of these had drain holes to reduce soil pore pressure. Catch basins were located along the curbs of roadways, and in the centre of backlanes. Roof drains entered the stormwater collection system (see Figure 3).

The outfall from the collection system of the catchment area consisted of a concrete pipe which discharged to a concrete pad. There was a drop in elevation of approximately 1 metre immediately downstream from the concrete pad. The discharge pipe was a 24 inch (610 mm) diameter pipe at a 0.6% slope. The maximum discharge at full pipe conditions, assuming a Manning roughness coefficient of 0.013, was estimated to be approximately 43 200 cubic metres per day (m^3/d).

The decision to utilize this particular stormwater collection system and outfall for the study was based upon several criteria, including:

1. The catchment area should be residential in nature, since residential catchment areas represent the largest land utilization within the Fraser River Estuary Study Area.

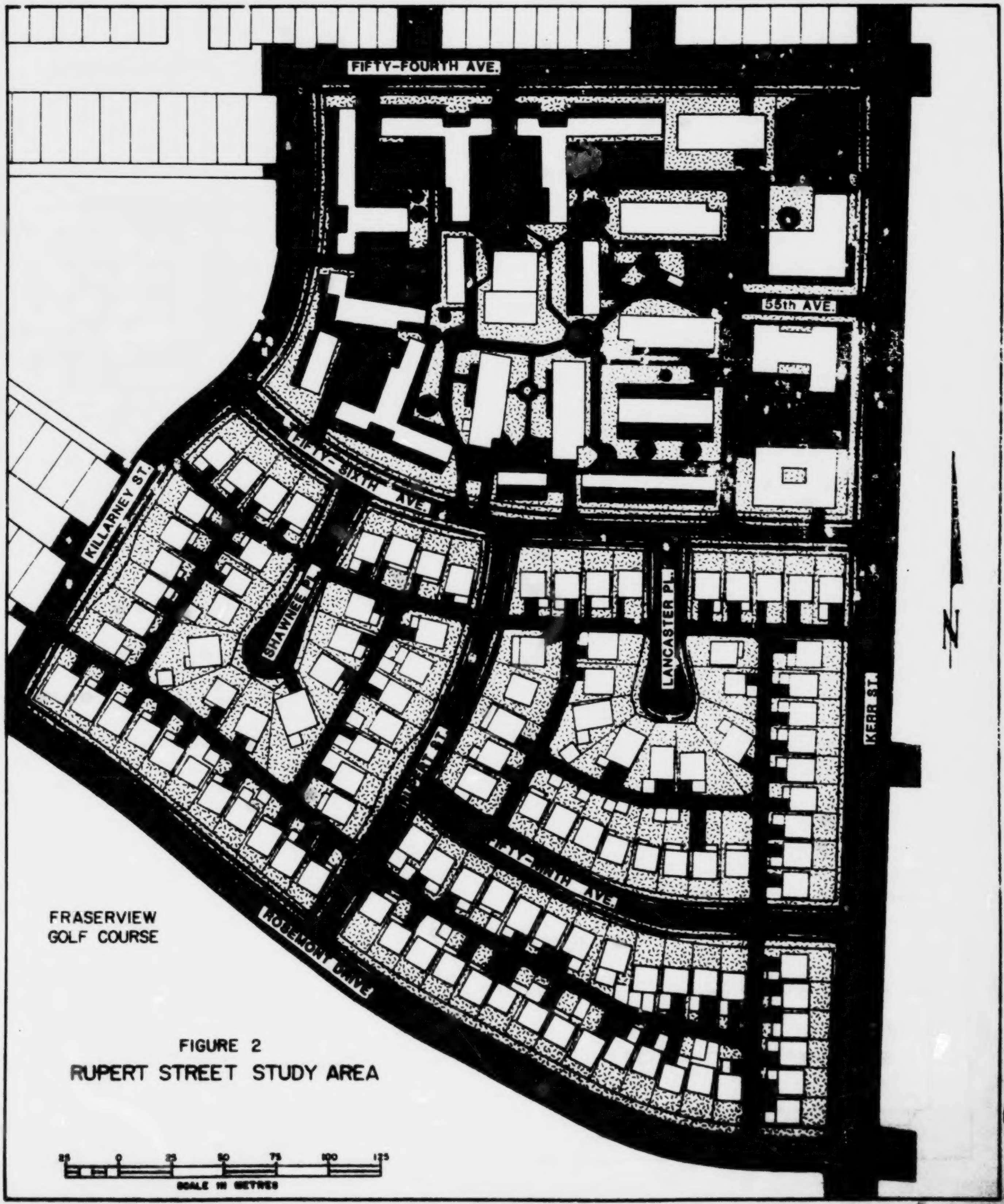

FIFTY-FOURTH AVE.
55th AVE.
FIFTY-SIXTH AVE.
KILLARNEY ST.
SHAWNEE PL.
LANCASTER PL.
KERR ST.
ROSEMONT DRIVE
FRASERVIEW GOLF COURSE
N
25 0 25 50 75 100 125
SCALE IN METRES

FIGURE 2
RUPERT STREET STUDY AREA

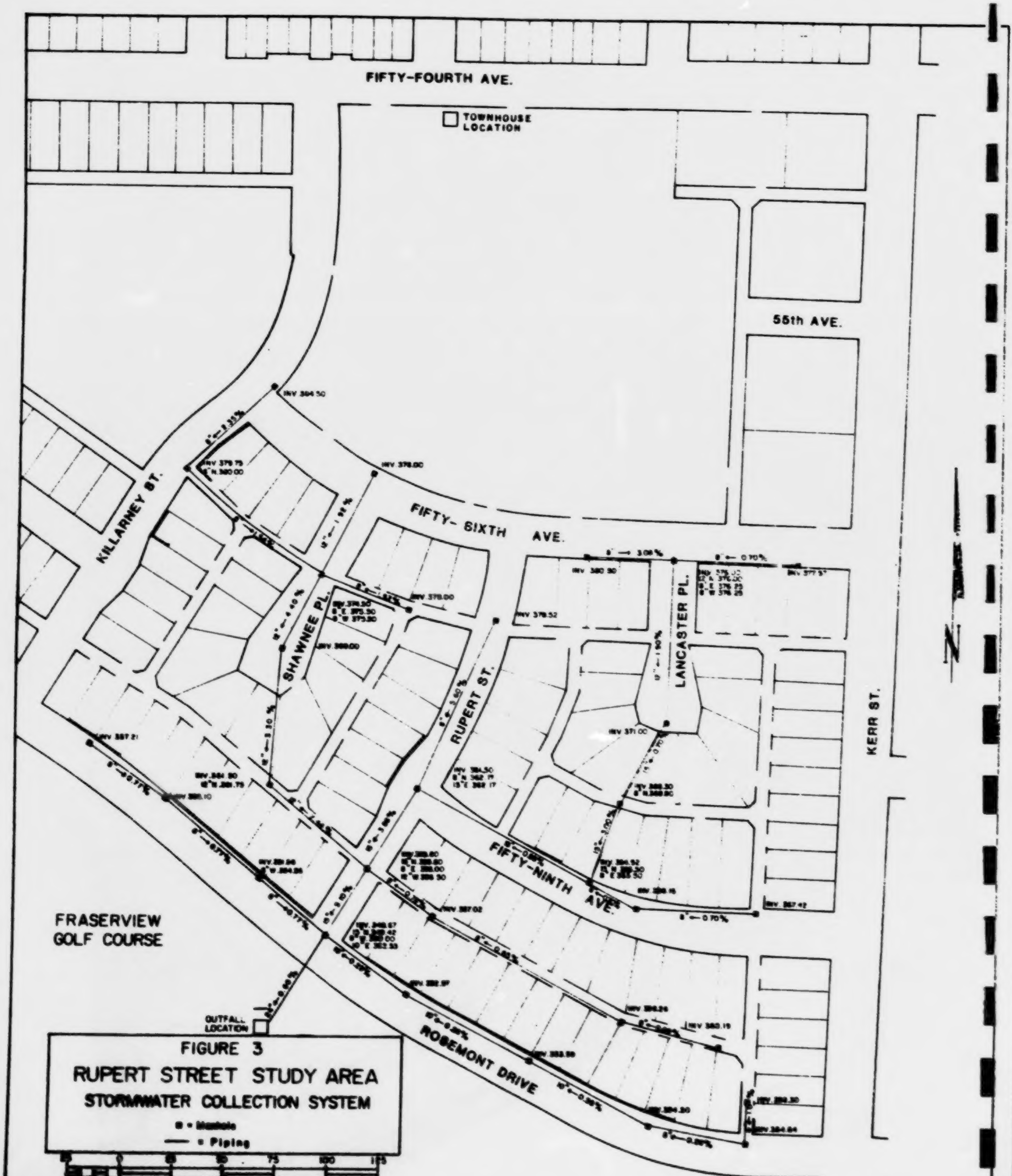


FIGURE 3
RUPERT STREET STUDY AREA
STORMWATER COLLECTION SYSTEM

FIFTY-FOURTH AVE.
TOWNHOUSE LOCATION
55th AVE.
FIFTY-SIXTH AVE.
KILLARNEY ST.
SHAWNEE PL.
RUPERT ST.
LANCASTER PL.
KERR ST.
FIFTY-NINTH AVE.
ROSEMONT DRIVE
FRASERVIEW GOLF COURSE
OUTFALL LOCATION
RAINGAUGE LOCATION
N
■ = Manhole
— = Piping
0
25
50
75
100
125
SCALE IN METRES

2. The catchment area size should be as large as possible, so that local peculiarities would be minimized.

3. The stormwater drainage within the area should be controlled so that stormwater erosion of stream banks does not introduce loadings not present in the runoff. This restricted the selection to areas where storm sewers existed.

4. The storm sewers should not have any cross connections with municipal-type sewage systems.

5. The storm sewer should not be affected by tidal influences, or other backwater effects. This generally ruled out stormwater outfalls located along the shores of the Fraser River.

6. The stormwater should eventually be discharged into the Fraser River.

7. Infiltration into the storm sewer should be a minimum.

8. The storm sewer should have a flat slope. Since the determination of loadings of contaminants from stormwater to the river was the prime objective of the study, flow measurements would be more accurate at slower stormwater velocities. Thus the slower the velocity of the stormwater at the point of measurement, the smaller would be the incremental discharge with each increment in water level.

9. The monitoring station should be easy to establish with few of the potential safety problems related to working in manholes.

10. The boundaries of the catchment area should be well defined.

3.2 MONITORING PROGRAM

Three sites were utilized for measurements of rainfall and dustfall quality, and one site was utilized for measurements of rainfall quantity within the catchment area. Measurements for stormwater flows and quality were made at the outfall where infiltration rates were also measured. The outfall from the storm sewer was fenced with security-type chain link fence to provide a working area around it. A garden-type shed was erected within the fenced area to shelter the recording and sampling equipment.

3.2.1 STORMWATER MEASUREMENTS

The measurement of stormwater flows was determined to be the most important aspect of the monitoring program. In order to measure flows continuously, a Parshall flume with a 9 inch (230 mm) throat and maximum 30 inch (762 mm) height was chosen as a conventional primary device. A Robert-Shaw capacitance liquid level sensor with its probe installed in a stilling well was chosen to measure levels. The output from the probe went to two linear strip chart recorders, operated in parallel, used to record levels on scales from 0 to 15 inches (0 to 381 mm) and 0 to 30 inches (0 to 762 mm). Two recorder scales were utilized to provide back-up capabilities as well as better resolution of levels at low flows. The Robert-Shaw capacitance liquid level sensor was chosen because results of work carried out under a Canada/Ontario agreement indicated that it had operated in a manhole for six months with no failures, while being exceptionally accurate (better than 1 percent)(2). A Parshall flume was chosen as the primary measuring device for several reasons. It was applicable for use at an outfall, was commercially available and well known, was accurate to ± 2 to 3%, created smaller head losses than weirs, and permitted large solids to pass freely.

Samples were collected either manually or with Sirco or Manning automatic samplers. Problems with condensation often caused operational problems with the Sirco samplers, problems which did not arise with the

Manning sampler since its circuitry was totally enclosed. Three automatic samplers were installed in order that water quality samples could be taken simultaneously at different time intervals, the smallest time interval being 3.5 minutes. A similar system had been suggested by Clark et al.(42). The samplers could be activated by a moisture sensitive switch when a storm event occurred. Generally, composite samples representing 15-minute time intervals were prepared from the discrete samples collected over short time intervals. The composite samples were initially analyzed for pH, oil and grease, total suspended and volatile suspended solids, specific conductance, TAC Colour, total alkalinity, organic and inorganic carbon, nitrogen in several forms (ammonia, organic, nitrate/nitrite, and Kjeldahl), BOD_5, chemical oxygen demand (COD), phenol, total phosphorus, total dissolved phosphorus, tannin and lignin, calcium, magnesium, and aluminum, copper, lead, manganese and zinc in total and dissolved forms.

In addition, grab samples were collected manually for total and fecal coliform. Grab samples were collected during May and June and in late September of 1981 and analyzed for polychlorinated biphenyls and the following pesticides: the insecticides diazanon, methoxychlor, and carbaryl (seven); the herbicides 2-4-D, mecaprop, and dicamba; and the fungicide captan. Grab samples were also collected during two periods when rainfall had not occurred for at least seventy-five hours, and during four rainfall events. The grab samples were subsequently used in 96-hour LC_{50} static bioassay tests using rainbow trout. One grab sample was also collected and used in a bioassay test using Daphnia as the test species.

3.2.2 PRECIPITATION AND AIR QUALITY SAMPLING

Precipitation was measured at a site (hereafter referred to as rainguage site) located just south-east of the catchment area off Kerr Street. It has been indicated that for small catchment areas, closely adjacent sites may be suitable(25). The raingauge used was the type that weighs rainfall and records the data on a 96-hour chart. In order to determine if rainfall was distributed evenly around the catchment area, rudimentary rainfall collectors were placed at the raingauge site, at the stormwater outfall, and at the townhouse complex on the northern extremity of the catchment area. Precipitation which was collected was subsequently measured with a graduated cylinder.

Rainfall cannisters were used to collect samples for precipitation quality analyses. These cannisters were also placed at these three locations but had to be opened manually during rainfall events. In addition, dustfall cannisters, which were always open to collect dustfall, were placed at the same locations. Precipitation samples were collected after each event or when the containers were full. The collected samples were subsequently analyzed for pH, strong and total acidity, phosphate, nitrate, cadmium, chromium, copper, lead, nickel, and zinc.

Dustfall cannisters were collected monthly or in the case of periods of extreme precipitation, when additional precipitation collected in the cannisters would have caused them to overflow. The overflow could have caused the dustfall collected to be washed out. The collected dustfall samples were subsequently analyzed for arsenic, cadmium, copper, lead, mercury, zinc, chloride, fluoride, and sodium.

3.2.3 INFILTRATION AND RUNOFF MONITORING

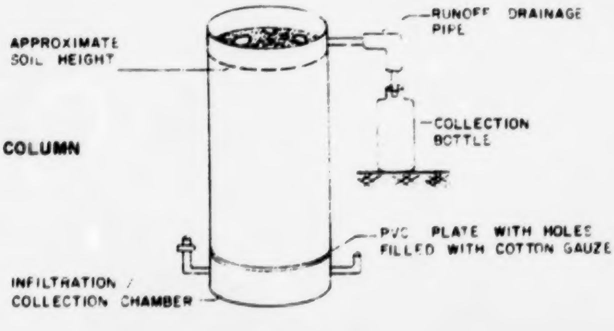
A description of the study area has been given in Section 3.1. The soil surface in the catchment area gently sloped from Fifty-forth Avenue in the North to Rosemont Drive (see Figure 2). Front yards were generally grass covered with varying numbers of trees and shrubs. Back yards were grass covered with some areas devoted to gardens, and others having trees and shrubs.

Soil moisture content samples were collected from the boulevard area on Rosemont Avenue. Samples were usually collected at an approximate one week interval. Grab samples were collected by removing the grass cover to an approximate five centimetre depth. Duplicate soil samples were then taken from the soil at this depth. Moisture contents have been expressed on a weight basis.

In order to simulate infiltration and runoff conditions, four soil columns were prepared. The soil columns were prepared using PVC pipe and in-situ soil which had not been disturbed. This required that large areas be manually excavated and that the pipe be carefully placed around the undisturbed soil. Once the pipe was in place, it was removed with the soil so that the final construction of the infiltration/runoff column could be completed. In addition, areas of soil on the top of the pipe which had been slightly disturbed and might increase infiltration were repaired using bentonite clay. The natural grass cover was maintained on the soil, and was cut throughout the study as required using scissors. A description of the soil which was contained in the infiltration/runoff columns is contained in Section 6.2.

Two of the columns had provision to collect runoff from the top of the column and infiltrate which passed through the column. These columns were approximately sixty centimetres in height. The actual soil columns, about 50 centimetres in height, rested on a PVC plate with a number of drainage holes. The holes were filled with cotton gauze to permit drainage but prevent clogging. An empty collection chamber was below the PVC plate. Collected infiltrates were removed with a hand held vacuum pump using the attachment provided (see diagram below). The other two columns, approximately 10 centimetres high, collected only runoff. Common to both types of collectors was the runoff collection section of the column. A drainage pipe permitted runoff to flow and accumulate in a plastic container (see diagram below).

INFILTRATION / RUNOFF COLUMN


RUNOFF DRAINAGE PIPE
APPROXIMATE SOIL HEIGHT
COLLECTION BOTTLE
PVC PLATE WITH HOLES FILLED WITH COTTON GAUZE
INFILTRATION / COLLECTION CHAMBER

PART II: PRESENTATION OF RESULTS

4.0 PRECIPITATION

Precipitation quality was measured at three sites in the catchment area. Continuous quantity measurements were made at one site, just to the south of the catchment area (see Section 3.2.2), while rudimentary quantity measurements were made at three sites.

The raingauge used to record precipitation quantities was initially spring powered, but later battery operated. Vandalism was an occasional problem since the raingauge had to be located in an open area, which was adjacent to a golf course.

The cannisters used to collect rainfall samples were also vandalized on occasion, even those protected by the "security fencing" at the outfall site. However this had little effect on the results since the rainfall cannisters were only opened during precipitation events.

4.1 QUANTITY

A daily record of precipitation for the period November 1980 to December 1981 has been included as Table 1. These data represent the quantity of precipitation which occurred over the catchment area.

The data indicate that the largest quantity of precipitation occurred during October 1981, when nearly 210 mm fell. The next wettest month was November 1981, when nearly 200 mm of precipitation fell. The three driest months were January, July, and August when 43.5 mm, 52 mm, and 55 mm respectively, fell. The data indicate that about 1625 mm of precipitation occurred in the period from December 1980 to December 1981, inclusive.

The largest number of hours during which precipitation fell was over 150 hours in December 1980. The next largest number of hours of precipitation was 134 in February 1981. The least number of hours of precipitation was 22 in July, 26 in August, and 40 in January, 1981. The data indicate that precipitation occurred during a total of over 1250 hours in the period from December 1980 to December 1981, inclusive.

To ascertain whether the precipitation during the period of record was of "normal" quantities, the monthly precipitation records for the Vancouver International Airport were compared. Table 3 compares data for the period of our study to that expected during "normal" precipitation years. The data indicate that approximately 37% more precipitation fell at the Airport during the study, than is "normal". This factor is important in determining "normal" loadings from stormwater to the river.

It is expected that during a year, about 100 mm more precipitation would occur at Rupert and Rosemont than at the Vancouver International Airport, according to the information on isohyets presented in Figure 2 of Ferguson and Hall(3). The data in Table 3 indicate that about 1692 mm of precipitation fell at the Vancouver International Airport. This is approximately 70 mm more than recorded at Rupert and Rosemont. However, malfunctions and vandalism which occurred at Rupert and Rosemont during several days could explain the difference of about 170 mm less recorded than anticipated by the records. This would not affect calculated runoff coefficients since these were determined only for individual runoff events which had a complete data base.

To determine whether rainfall was evenly distributed throughout the catchment area, precipitation collectors were placed at three sites around the catchment area. These rudimentary devices were placed in the ground, and were withdrawn after each rainfall event or at regular intervals to measure volumes collected in a graduated cylinder. Oil was placed in the cylinders to prevent evaporation during warm weather. Antifreeze was used during colder periods.

The data collected throughout the study area are included in Table 2. The data indicate that on a monthly basis, precipitation was measured within about 10% of what was recorded at the raingauge collector for all months except the December 1980 to February 1981 period and the month of May 1981. In the former period the discrepancy may have resulted from snowfall.

Student's "t tests" were performed to determine if a statistically valid difference existed between sites for the quantity of rainfall collected. A probability level of 0.05 was chosen. The tests for each of the comparisons between the townhouse/raingauge, townhouse/outfall, and raingauge/outfall indicated that no significant difference ($p<0.05$) existed between any of these sites, in the long-term. This does not mean however, that individual variations on a sample basis may not have been present.

4.2 QUALITY

Precipitation quality was measured at three stations between October 31, 1980 and November 30, 1981. The data are included as Tables 4a and 4b. Table 4a presents the data for the three sites on an event basis, while Table 4b presents a data summary for each site. A description of the sites is included in Section 3.2.2. The variability between the sites was evaluated statistically and the results for different parameters are given in Table 29.

Table 4c has been included to provide data comparisons with two sites within British Columbia, one at Revelstoke and one located between Prince Rupert and Terrace. These sites represent two pristine areas, one inland and one near the West Coast. The data for the Prince Rupert/Terrace site (located approximately equidistant from Prince Rupert and Terrace) were collected on an event basis (as were data reported herein) from September 1980 to November 1981(31). Data reported for Revelstoke were based on continuously collected samples collected over one month periods from September 1979 to December 1980(32)(33)(34)(35)(36).

4.2.1 pH

More than 100 values were recorded for pH at each of our three sites. The median values were 4.84 at the townhouse, 4.87 at the raingauge, and 4.86 at the outfall (Table 4b). This indicates that in general, rainfall within the catchment area is acidic, i.e. generally less than a pH of 5.6, the value for pure rain water in equilibrium with carbon dioxide at 25°C. Data in Table 29 indicate no significant variation between sites at the 0.05 level of probability when the data were examined with either the Student's "t test" or the "F" test.

Samples collected at the Prince Rupert/Terrace site had a median pH value of 5.03 (Table 4c). Composite samples collected over a one month period at Revelstoke had a median value of 5.5. These data indicate that the pH values measured in Vancouver were slightly less than those at the other coastal location, but appreciably less than at the inland location.

Twenty-seven storm events (Table 4a) had more than one pH value recorded for each station throughout the storm event. The data indicate that for the 75 samples collected in the 27 storm events, each sample was collected over a period ranging from 1 hour to 26 hours with the mean collection time being 8.5 hours. During these 27 storm events, 10 storms had decreasing pH values, 8 storms had increasing pH values, 2 storms each either decreased then increased, or vice-versa, while the remaining 5 storms randomly changed from increasing to decreasing, or vice-versa, several times.

4.2.2 ACIDITY

Strong and total acidity values were measured using Gran's plots(46) at each of the three sites approximately 75 times throughout the study. Strong acidity values measured in Vancouver (Table 4b) were higher than at the site between Terrace and Prince Rupert (Table 4c). No data were collected at the inland station at Revelstoke.

Total acidity values were higher at the Vancouver site than further north along the coast at Prince Rupert/Terrace. No data were collected at the inland station near Revelstoke for total acidity.

4.2.3 IONS

Ions measured throughout the study included calcium, chloride, magnesium, potassium, phosphate, sodium, and sulfate. Approximately 50 measurements were made for each of these ions at each of the three sites, except in the case of phosphate when approximately 100 measurements were made at each of the three sites.

4.2.3.1 Calcium

Calcium values at the Prince Rupert/Terrace station were considerably lower than measured at the Vancouver catchment. Values measured at Revelstoke were similiar to those at the Vancouver catchment.

4.2.3.2 Chloride

Median chloride values at Prince Rupert/Terrace and at Revelstoke (Table 4c) were considerably less than the mean values recorded for the Vancouver catchment. This indicates either contamination from air emissions in Vancouver or more likely, that chloride picked up over the Pacific Ocean is released relatively quickly over the West Coast. Thus the Prince Rupert/Terrace site receives chloride concentrations more typical of inland locations.

4.2.3.3 Magnesium

Magnesium values recorded at the Prince Rupert/Terrace site and the Revelstoke site (Table 4c) were considerably less than recorded at the Vancouver catchment area (Table 4b), probably for the same reason as chloride.

4.2.3.4 Potassium

Potassium values at the Prince Rupert/Terrace site (Table 4c) were lower than at the other stations. The values measured at Revelstoke were similar to those measured at the raingauge in the Vancouver catchment area.

4.2.3.5 Phosphate

Phosphate values were only recorded at the Prince Rupert/Terrace site (Table 4c), and these were considerably lower than those recorded further south on the West Coast at Vancouver.

4.2.3.6 Sodium

Sodium values at the Prince Rupert/Terrace site and at Revelstoke (Table 4c) were considerably less than recorded at the Vancouver catchment area. As was indicated for chloride, sodium would likely be released relatively quickly over the West Coast, with the inland site at Prince Rupert/Terrace receiving sodium at levels similar to those at the site further inland.

4.2.3.7 Sulphate

Sulphate values at Prince Rupert/Terrace and at Revelstoke (Table 4c) were considerably less than recorded at the Vancouver catchment area (Table 4b). As was indicated for chloride and sodium, sulphate would seem to be released relatively quickly over the West Coast after being picked up over the Pacific Ocean.

4.2.4 HEAVY METALS

Heavy metals measured in precipitation samples included cadmium, copper, lead, and zinc. Approximately 65 values for each of these parameters were recorded at each of the three sites. Only aluminum was measured at the Prince Rupert/Terrace site, while no metals values were measured at Revelstoke.

Mean values for lead were 0.046 mg/L at the townhouse, 0.035 mg/L at the raingauge, and 0.029 mg/L at the outfall (Table 4b). A significant difference existed between the rainguage and outfall sites and the townhouse and outfall sites for the "F" test for lead. The trend of higher mean lead values being recorded at the townhouse site than at the other two sites is also evident in the air quality data (see Section 5.2.4). The close proximity of this station to a busy roadway with associated vehicular emissions containing lead, is likely the origin of these high values.

Data in Table 29 indicate that for a 0.05 level of probability, a significant variability existed between all sites for zinc with the "F" test. Mean zinc values recorded were 0.050 mg/L at the townhouse, 0.062 mg/L at the raingauge, and 0.057 mg/L at the outfall (Table 4b).

4.2.5 NITROGEN

Three forms of nitrogen were measured, and these included ammonium, nitrate, and nitrite. Approximately 100 measurements were made for each of ammonium and nitrate nitrogen at each of the three sites. Approximately 60 values were recorded for nitrite nitrogen at each of the three sites.

4.2.5.1 Ammonium Nitrogen

Values at the Prince Rupert/Terrace site and at Revelstoke (Table 4c) were considerably less than measured for the Vancouver catchment area (Table 4b).

4.2.5.2 Nitrate Nitrogen

Values at the Prince Rupert/Terrace site and at Revelstoke (Table 4c) were approximately one-half those recorded at the Vancouver catchment area (Table 4b).

4.2.5.3 Nitrite Nitrogen

Nitrite values were not recorded at Prince Rupert/Terrace or Revelstoke.

4.3 DISCUSSION

Precipitation during the period of the study was approximately 37% greater than normal.

When pH values were recorded throughout a storm using a number of samples no trend of either increasing or decreasing pH was apparent, although about 7% more storms showed indications of a decreasing rather than an increasing pH. This tends to partially contradict the literature (section 2.4), which indicates that precipitation during the early part of a large storm contains higher concentrations of scavenged materials, gases, and particulates. However to fully explain the results, data on mass air movements throughout a storm would have to be examined, a study far beyond the scope of this report.

Concentrations of metals tended to be low at all sites. Lead values consistently were higher at the townhouse site than the other two sites, likely due to vehicular emissions containing lead.

Samples collected at the Vancouver catchment area, as well as those referenced for the Prince Rupert/Terrace site, were collected on an event basis. Samples collected and reported for Revelstoke were collected on a continuous period over intervals of approximately one month. The samples were analyzed at the end of the one month period. It is likely that there may be deviations in values reported for pH, nitrate and ammonium from values which would have been reported had the samples been event samples and analyzed immediately upon collection. Oden has indicated that "a monthly sample will contain a succession of rains of different composition which leads to chemical reactions and internal weathering during the sampling period. This increases both the pH and alkalinity of the composited sample in relation to what would be the result with an event sampling technique"(40). The considerably larger data base for the Vancouver catchment area versus that for Prince Rupert/Terrace or Revelstoke may also affect the relevance of some values.

The quality of precipitation measured at each of the three Vancouver sites generally could be described as "acidic" in nature. Median pH values were all less than 5.6, the value at which water is in equilibrium with carbon dioxide. Values measured further north along the West Coast at Prince Rupert/Terrace but further inland than the Vancouver site were approximately the same. However, values measured at Revelstoke were higher. These differences could be attributable to differences in total yearly precipitation, or the origin of the air masses associated with the precipitation. Acidity present was generally in the form of weak acids, with strong acids composing less than one-half of the total acidity measured. This was also the situation at the Prince Rupert/Terrace site, although total acidity values at the Prince Rupert/Terrace site were lower than at the Vancouver catchment area.

A considerable difference existed in the values of chloride, magnesium, phosphate, sodium and sulfate measured within the catchment area, at Prince Rupert/Terrace and at Revelstoke. This can likely be explained by the fact that these ions are picked up over the Pacific Ocean and are deposited relatively quickly over the West Coast area. Oden has indicated that the oceans are the main source of chloride(40). Thus values closer to the coast, as at the catchment area, are higher than those measured further inland. The other possibility is that ions such as nitrate, ammonium, and phosphate originate from emission sources in the Vancouver area.

The "F" test and Student's "t test" were used to compare the variability of values measured in the precipitation at the three monitoring sites. Values for pH, chloride, sodium, and magnesium were not significantly different between sites. Values for potassium, phosphate, copper and zinc were significantly different between all sites tested. Sulphate values were significantly different at the raingauge site compared to the other two sites. Calcium values were significantly different between the townhouse site and the other two sites. The outfall site showed significant variability for values of total acidity, nitrate, nitrite, ammonia, cadmium and lead. The variability at the outfall site may be accounted for by the fact that the site was in a heavily treed area, and material dropping from the trees was carried into the sample containers during precipitation.

5.0 AIR QUALITY

Dustfall measurements were made at three sampling stations. Analyses included ions and metals in dustfall and total dustfall.

The dustfall cannisters were the subject of vandalism, although not all concurrently. The problem of vandalism was also evident at the outfall site, which was protected with "security fencing".

5.1 SOLUBLE COMPONENTS

Soluble components measured in dustfall included chloride, fluoride, and sodium. Fifteen measurements for each of these were made at the outfall site, while 17 measurements were made at both the townhouse and raingauge sites.

5.1.1 CHLORIDE

Mean recorded chloride values were 0.25 $t/km^2/mo$ at the townhouse, 0.20 $t/km^2/mo$ at the raingauge, and 0.21 $t/km^2/mo$ at the outfall (Table 5b). No significant difference in values was found between any of the sites with either a Student's "t test" or an "F" test at the 0.05 level of probability (Table 30).

5.1.2 FLUORIDE

Fluoride values were all less than the detection limit of 0.007 $t/km^2/mo$ at all three sites.

5.1.3 SODIUM

Mean recorded sodium values were 0.12 $t/km^2/mo$ at the townhouse and 0.11 $t/km^2/mo$ at each of the rainguage and the outfall sites (Table 5b).

No significant difference in values was found between any of the sites with either a Student's "t test" or an "F" test at the 0.05 level of probability (Table 30).

5.2 METALS

Metals measured included cadmium, copper, lead, mercury, and zinc and the metalloid, arsenic. These were generally measured in the soluble, insoluble, and total forms.

5.2.1 ARSENIC

Arsenic was measured 9 times at each of the raingauge and the townhouse sites and 8 times at the outfall. It was generally found to be soluble, with the insoluble fraction being recorded as less than the detection limit of 0.0007 $t/km^2/mo$ at each of the three sites. Total arsenic values reached a high of only 0.0007 $t/km^2/mo$ at each of the three sites, with the majority of values not being measurable (i.e. $<0.0007\ t/km^2/mo$) (Table 5b).

5.2.2 CADMIUM

Cadmium values were measured on 10 occasions at each of the townhouse and raingauge sites, and on 9 occasions at the outfall. Cadmium was not detected in either the soluble or insoluble fractions, with all values at all three sites being $<0.0004\ t/km^2/mo$ (Table 5b).

5.2.3 COPPER

Mean total copper values were 0.0009 $t/km^2/mo$ at the townhouse, 0.0011 $t/km^2/mo$ at the raingauge, and 0.0010 $t/km^2/mo$ at the outfall (Table 5b). No significant difference in total copper values was found between any of the sites when a Student's "t test" or an "F" test was performed (Table 30).

5.2.4 LEAD

Mean total lead values were 0.0041 t/km^2/mo at the townhouse, 0.0018 t/km^2/mo at the raingauge, and 0.0016 t/km^2/mo at the outfall (Table 5b). The occurrence of higher lead values at the townhouse site was also apparent from the precipitation data (see Section 4.2.4). As can be seen for the lead data in Table 5b, these higher values were evident for both the soluble and insoluble lead fractions.

The application of a Student's "t test" found that a significant difference in values for total, soluble, and insoluble lead existed between the townhouse and the outfall sites, and between the townhouse and the raingauge sites. However, no significant difference in values was found between the raingauge and outfall sites at the 0.05 level of probability (Table 30). These differences may be accounted for by vehicular emissions from the nearby roadway to the townhouse location.

5.2.5 MERCURY

No significant difference in total or soluble mercury values was found between any of the sites when a Student's "t test" was performed at the 0.05 level of probability (Table 30). Mean values and ranges are reported in Table 5b.

5.2.6 ZINC

Mean total zinc values were 0.0040 t/km^2/mo at the townhouse, 0.0034 t/km^2/mo at the rainguage, and 0.0057 t/km^2/mo at the outfall (Table 5b).

5.3 PARTICULATE MATTER

Dustfall particulates consist of those particles in the air that settle out due to gravity. They consist of particles 20 micrometres in diameter and larger.

Data have also been reported for samples collected from 1973 to 1977 inclusive at the Manitoba Works Yard (250 West 70th Avenue), a site near the Rupert and Rosemont catchment area. The data were originally reported by the Greater Vancouver Regional District(44, 45).

5.3.1 TOTAL

Mean total particulate values were 3.49 $t/km^2/mo$ at the townhouse, 2.52 $t/km^2/mo$ at the raingauge, and 4.75 $t/km^2/mo$ at the outfall (Table 5b). These are comparable to a mean value of 3.3 $t/km^2/mo$ recorded at the Manitoba Works Yard from 1973 through 1977.

The Pollution Control Board has issued objectives for ambient air(37). These call for total particulate matter not to exceed a range from 5.3 $g/m^2/mo$ to 8.8 $g/m^2/mo$. (The units $g/m^2/mo$ and $t/km^2/mo$ are equivalent). The data indicate that the mean values met the objectives at all sites, however, some recorded values at the townhouse and outfall were outside the range.

Kotturi has reported ambient dustfall values for several sites considered pristine near Chetwynd(38)(39). Values for total particulate at three sites measured in two years ranged from 0.35 $g/m^2/mo$ to 7.14 $g/m^2/mo$, with a mean value of 1.82 $g/m^2/mo$. These data indicate that the dustfall levels for the catchment area were about twice the levels found under pristine conditions.

5.3.2 SOLUBLE

Mean values for these sites are indicated in Table 5b. All mean values except at the outfall were less than the mean value of 2.6 t/km^2/mo recorded at the Manitoba Works Yard from 1973 through 1977.

5.3.3 INSOLUBLE

Mean values for these sites (Table 5b), except at the outfall site, were less than the mean value of 1.7 t/km^2/mo recorded at the Manitoba Works Yard from 1973 through 1977.

5.4 DISCUSSION

Dustfall values recorded were generally higher than for pristine areas, but lower than the range of values cited in the ambient air quality objectives. Dustfall values were generally of the same order of magnitude as those reported for the nearby Manitoba Works Yard by the Greater Vancouver Regional District.

When the data were tested at the 0.05 level of probability, no significant difference between monitoring sites was indicated for soluble sodium, soluble chloride, total copper, or soluble mercury. Total, soluble, and insoluble particulates recorded at the raingauge were significantly different from those at the other two sites. Since mean values at the raingauge were lower than for the other sites, the significant difference between the raingauge and the other sites can be explained by the fact that the dustfall collection cannisters at the raingauge may have been sheltered by a residence from the dust originating from Kerr Avenue.

Soluble ash and soluble zinc values were significantly different at the outfall compared to the other two sites. Insoluble ash, as well as total, soluble, and insoluble lead were significantly higher at the townhouse than at the other sites, likely due to high vehicular emissions associated with this site. These high lead values were also noted in analyses of precipitation.

6.0 INFILTRATION AND RUNOFF

The hydrologic cycle is a method of calculating a water balance for a system. In general form, the hydrologic cycle states that precipitation which falls on the earth is ultimately:

1. placed into the soil through infiltration, or
2. returned to the atmosphere through evaporation or transpiration processes.

Numerous pathways can exist for this cycle.

The amount of water which can run off the soil surface depends upon the intensity of the rainfall, the type of soil, the moisture content of that soil (see Section 2.1), soil structure, and soil surface conditions.

6.1 SOIL MOISTURE CONTENT

Duplicate surface soil samples were collected throughout the study in special tin cans for subsequent determination of soil moisture content. Samples were usually collected from the boulevard on Rosemont Drive adjacent to the outfall location. The type of soils in the boulevard are described in Section 2.

Data collected throughout the study on moisture content are included as Table 6, and the mean values for surface soils presented graphically as Figure 4. Although variations exist within specific time periods, presumably associated with variations related to precipitation events, the mean soil moisture content was about 34% from December 1980 through June 1981. This decreased to about 27% during the July through September period, because of lack of rainfall. Thereafter the moisture content began to increase again to about the 34% range.

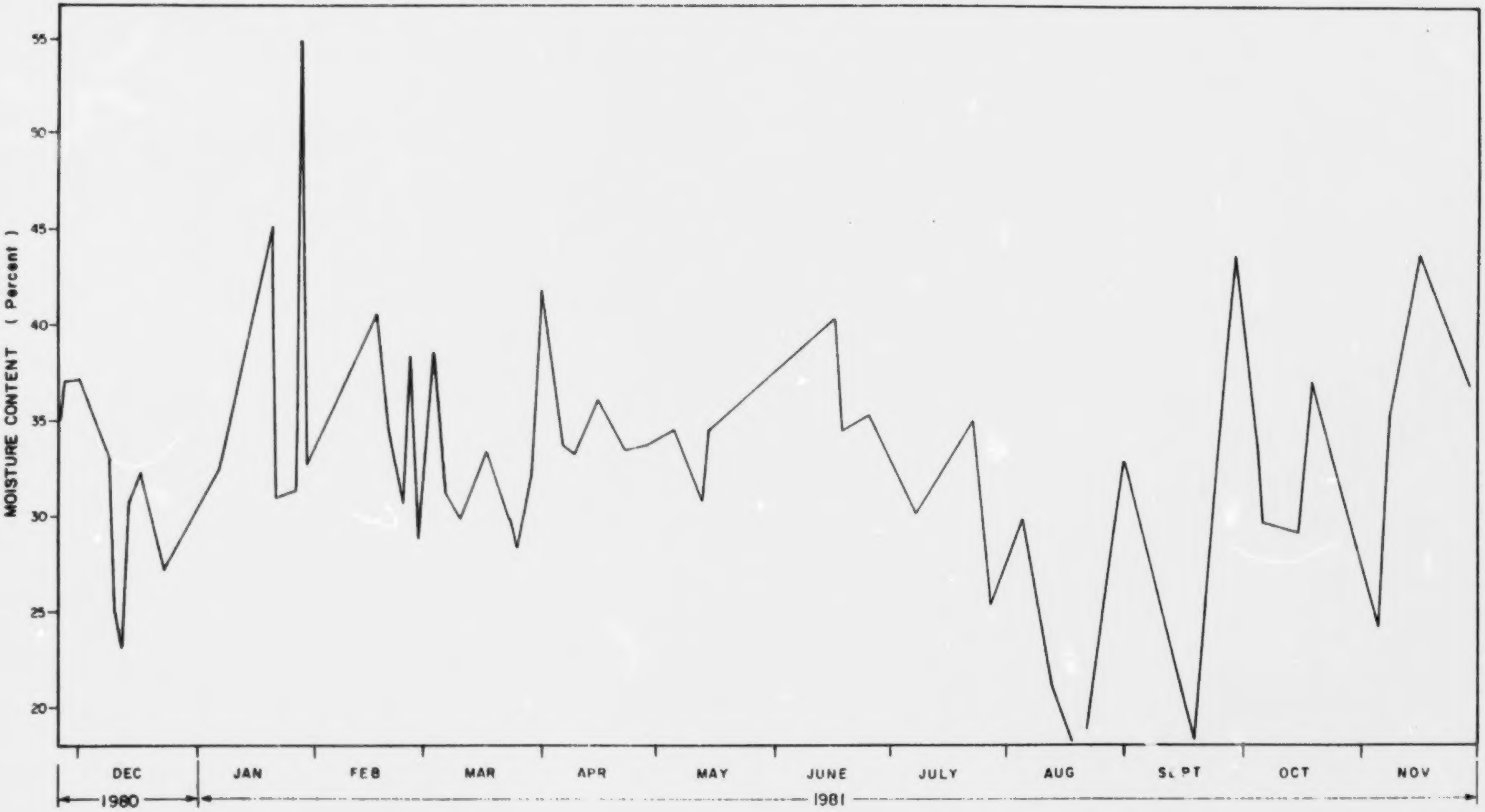


FIGURE 4 . MEAN SURFACE SOIL MOISTURE CONTENTS , DECEMBER 1980 THROUGH NOVEMBER 1981

It is anticipated that due to lower soil moisture content, the runoff during the July through September period would be less than during other times of the year. Such a result is indicated by data for runoff coefficients in Table 9, which show that during the months of July and August, the highest value for R was only 0.35.

6.2 INFILTRATION

Upon dismantling the two infiltration/runoff columns of undisturbed soil which were used throughout the study, the soil gradation was found to differ greatly between the two columns. One column had large quantities of sand and gravel, with some rocks of approximately four inch diameter. The infiltration information for this column appears on the third line of Table 7.

The second infiltration/runoff column had a layer of clay approximately four inches thick under the topsoil. There was organic material throughout the column height and the sand and gravel present had smaller sized particles than did the first column. The infiltration information for this column is given on the fourth line of Table 7.

Based upon the soil contents and gradations found in the two columns, one would expect that infiltration quantities to be much larger in the first column, since the soil gradation consisted of larger sized particles. The presence of smaller sized clay and sand particles in the second column would be expected to reduce the rate of infiltration. One would anticipate larger quantities of runoff to occur from this column than from the first infiltration/runoff column.

The total runoff and infiltration for the columns, shown at the end of Table 7, indicate that as expected, approximately 75% more infiltration was recorded for the first infiltration/ runoff column that for the second. In addition, and as expected, approximately 85% more runoff was recorded for the second infiltration/ runoff column than for the first.

Since the undisturbed soil samples had been prepared from sites in the catchment area, it would be expected that infiltration and runoff rates would vary throughout the area, depending upon the soil composition at any particular site.

7.0 STORMWATER RUNOFF

A description of methods used to measure quantity and quality of stormwater runoff is included in Section 3.2.1.

The system to measure flows using a flume, a capacitance probe and linear chart recorders performed with little maintenance. The capacitance probe itself was problem-free. The linear chart recorders, which had internal batteries, performed with few problems once the internal batteries were bypassed as a power supply and replaced with 12-volt batteries. To ensure continuity in data acquisition, a back-up set of recorders was maintained. Problems usually arose if the internal batteries started to withdraw power from the 12-volt batteries. Battery maintenance was a major part of operating this system and the automatic water quality samplers.

The automatic Sirco samplers were generally unreliable due to condensation problems, and most sampling was done manually, if possible. However, the automatic Manning sampler performed well. Although the moisture sensitive switch generally activated the samplers, seldom did all samplers commence sampling when required to do so. One source of problems was the batteries, which had to be at full charge to switch on the samplers. Secondly, the samplers had to be used with their covers in place. Several internal electrical problems also caused breakdowns.

7.1 QUANTITY

A daily summary of flows measured at the outlet of the stormwater collection system, is included as Table 8. The largest total monthly flow occurred in December 1980 when about 24 300 m^3 was discharged. The next largest flow occurred in November 1981 when about 23 500 m^3 was discharged. These flows are equivalent to an average daily flow of 784 m^3/d. Higher average daily flows were actually recorded during October 1981 (797 m^3/d), and early December 1981 (1023 m^3/d).

Ferguson and Hall(3) have indicated that a runoff coefficient (R) of 0.45 is a value typical of residential development. Runoff coefficients for 145 storms from January 1981 to November 1981 inclusive, have been tabulated in Table 9 from the formula at the end of that table and only for events with complete data for runoff and precipitation (i.e. no equipment problems). The mean value for R was 0.40, the range from 0.03 to 0.94. The fifth, tenth, ninetieth, and ninety-fifth percentile values were 0.07, 0.13, 0.75 and 0.83, respectively.

The calculated value of R will depend upon the period of time during which runoff is assumed to be occurring. In this study, the time period was determined by taking the period during which the level in the flume exceeded the original level, just before rainfall started. In calculating R and in obtaining the mean value of 0.40, the base dry weather flow was not subtracted from the total flow. This adjustment was not made since R is generally used as a basis for sewer design, and the base dry weather flow must be carried at all times.

A multiple linear regression was used to explain the effects of the variables: antecedent dry weather (ANT), maximum precipitation intensity during a storm (MAX), the storm duration (DUR), and the average storm precipitation intensity (AVGINT) on the runoff coefficient from storm events. It must be emphasized that the results were based upon data collected during only one year. A discussion of the concepts of multiple linear regression has been included in Cain and Swain(27). The data used in this analysis are included as Table 21.

If the four variables affecting R were independent of each other, then their effect on the runoff coefficient could be determined using separate linear regressions. However, the variables are not independent, as shown by the non-zero correlation coefficients in Figure 5 where the variables were plotted against each other. Thus it was necessary to use a multiple linear regression analysis.

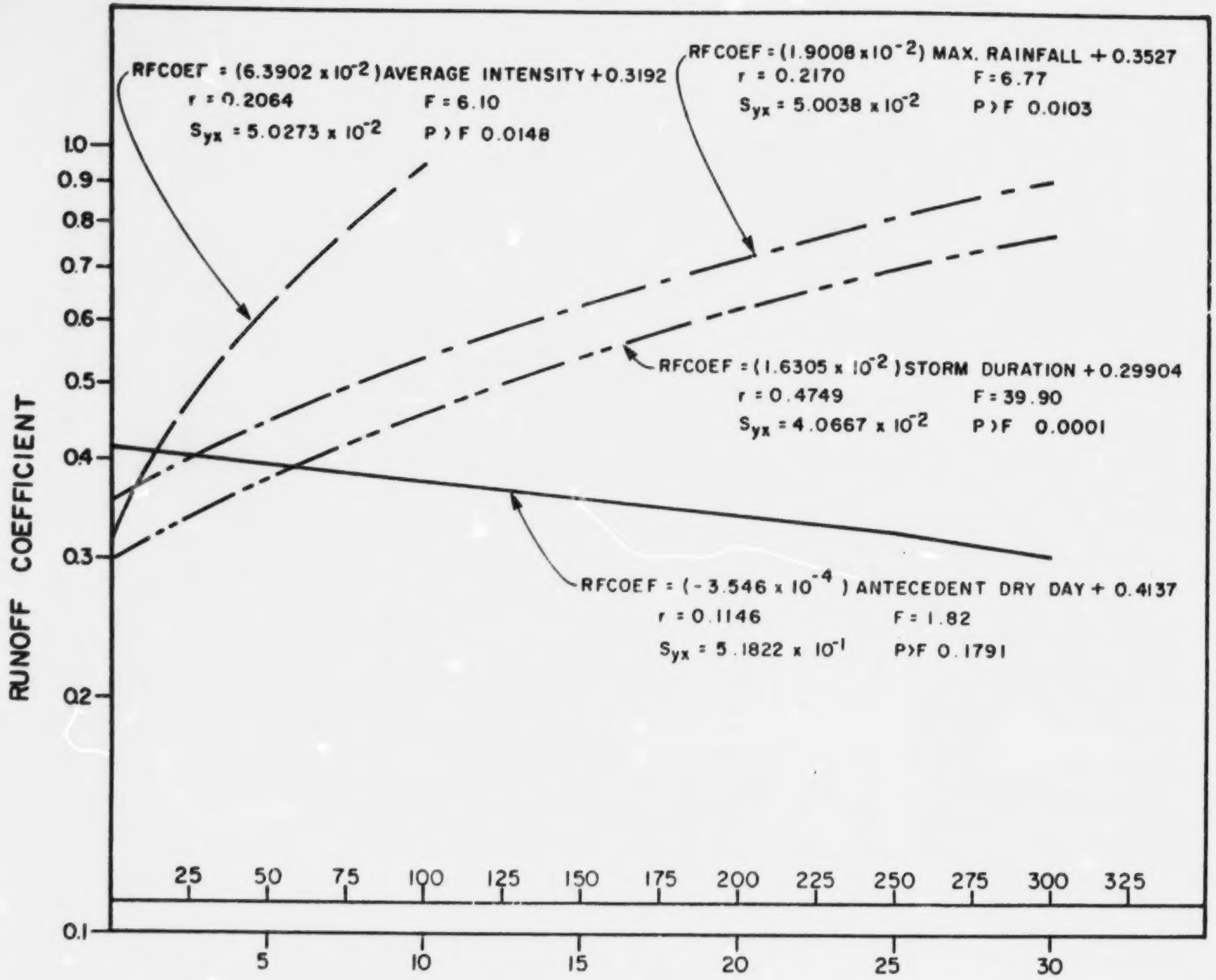


FIGURE 5 . RUNOFF COEFFICIENT AS A FUNCTION OF ANTECEDENT DRY DAYS , AVERAGE INTENSITY , MAXIMUM HOURLY RAINFALL AND STORM DURATION

Multiple linear regression can be viewed as a means of assessing how much of the total variance of the runoff coefficient can be explained by the combined effect of the four variables. The multiple regression analysis predicted was:

$$R = 0.2523 + 0.07462\ \mathrm{AVGINT} + 0.01639\ \mathrm{DUR} - 0.0146\ \mathrm{MAX} - 0.0003337\ \mathrm{ANT}$$

For this equation, the multiple correlation coefficient was 0.5026, which means that only about 25% of the runoff coefficient variability can be explained by these four variables. The most important of the tested variables was the average storm duration, followed by the maximum hourly rainfall and the average storm intensity. The antecedent dry weather had little effect on R. Other factors which were not taken into account, but which may be important, include the amount of non-pervious areas in the catchment area and evaporation rates.

7.2 QUALITY

Discharges at the Rupert and Rosemont site were sampled and analyzed during both dry and wet weather flow conditions. A summary of the values for different constituents has been included in Table 10 for dry weather and Table 11 for wet weather. Loadings of suspended solids, chemical oxygen demand, total organic carbon, total phosphorus, total nitrogen, aluminum, lead, copper and zinc for both dry and wet weather flow conditions have been calculated and are presented in Tables 12 for dry weather and 13 for wet weather. The variation of certain parameters with flow has been plotted for two storms, in Figures 6 and 7.

Following is a discussion of some of the more important constituents analyzed in the stormwater. Where flow-weighted mean concentrations are noted, they have been determined according to the following formula:

$$C_{FA} = \frac{\sum_{i=1}^{n} Li}{\sum_{i=1}^{n} Fi}$$

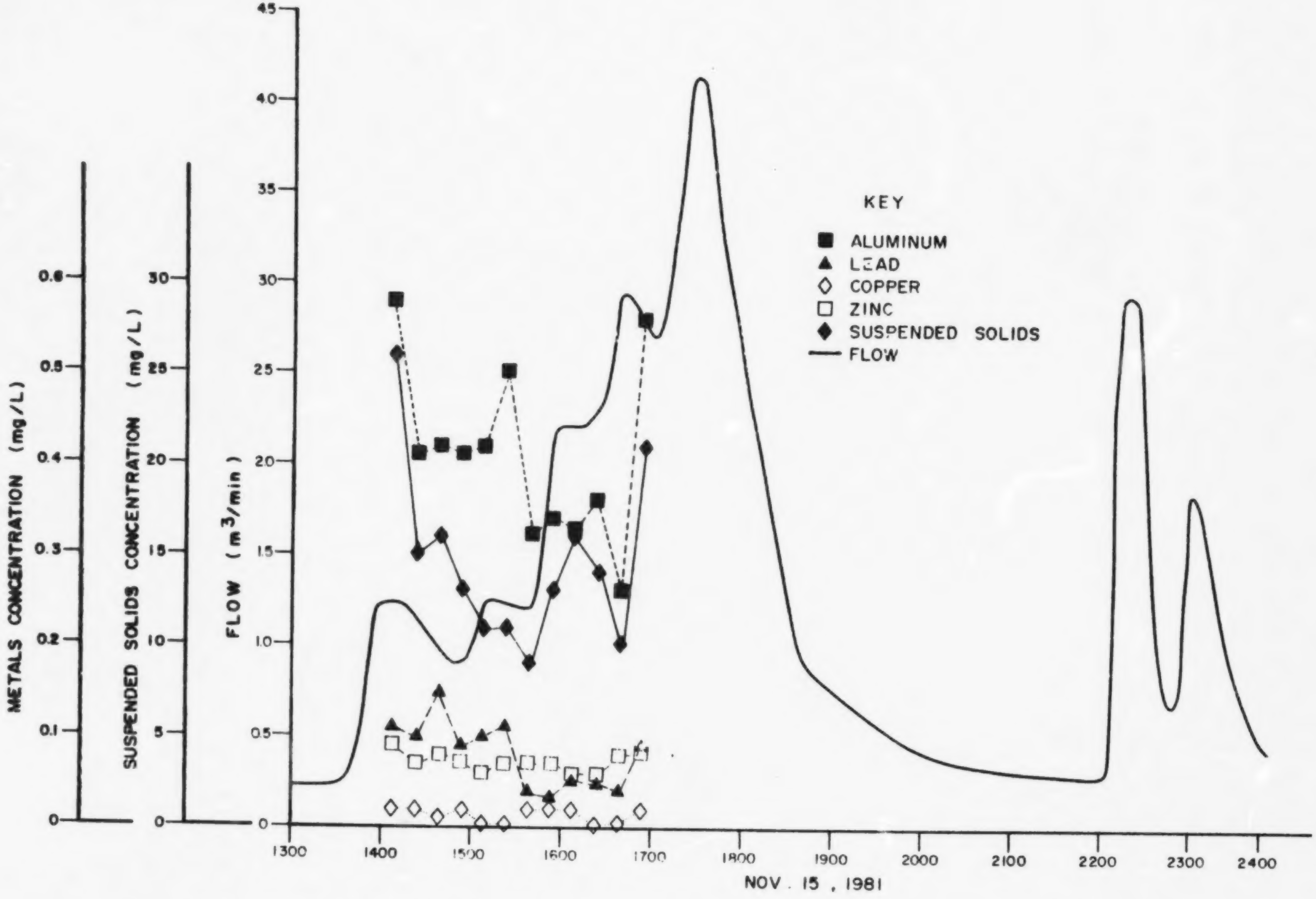


FIGURE 6 FLUCTUATIONS IN CONCENTRATIONS OF SELECTED PARAMETERS IN STORMWATER RUNOFF FOR THE FIRST THREE HOURS OF A LARGE STORM EVENT

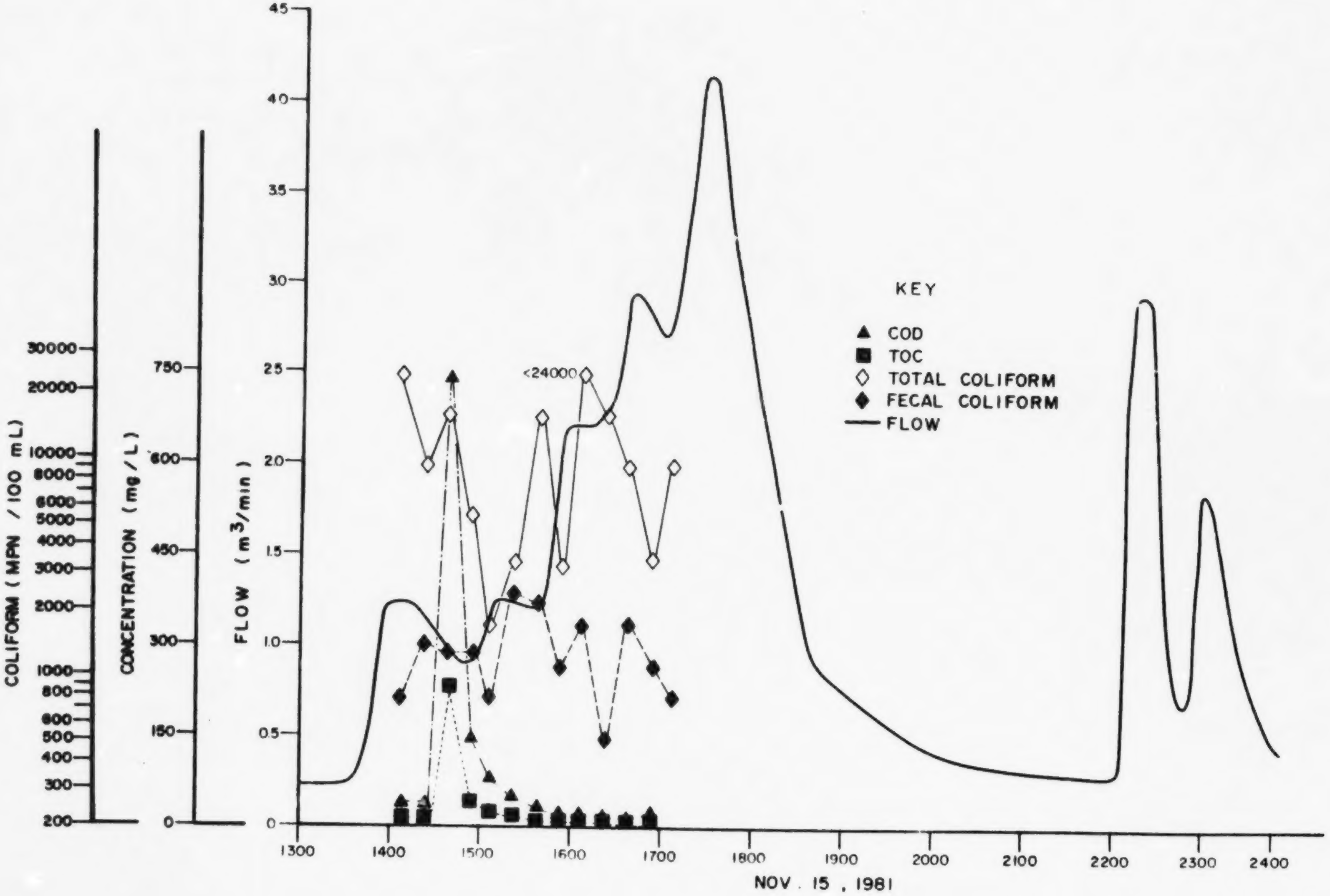


FIGURE 6 (Continued) FLUCTUATIONS IN CONCENTRATIONS OF SELECTED PARAMETERS IN STORMWATER RUNOFF FOR THE FIRST THREE HOURS OF A LARGE STORM EVENT

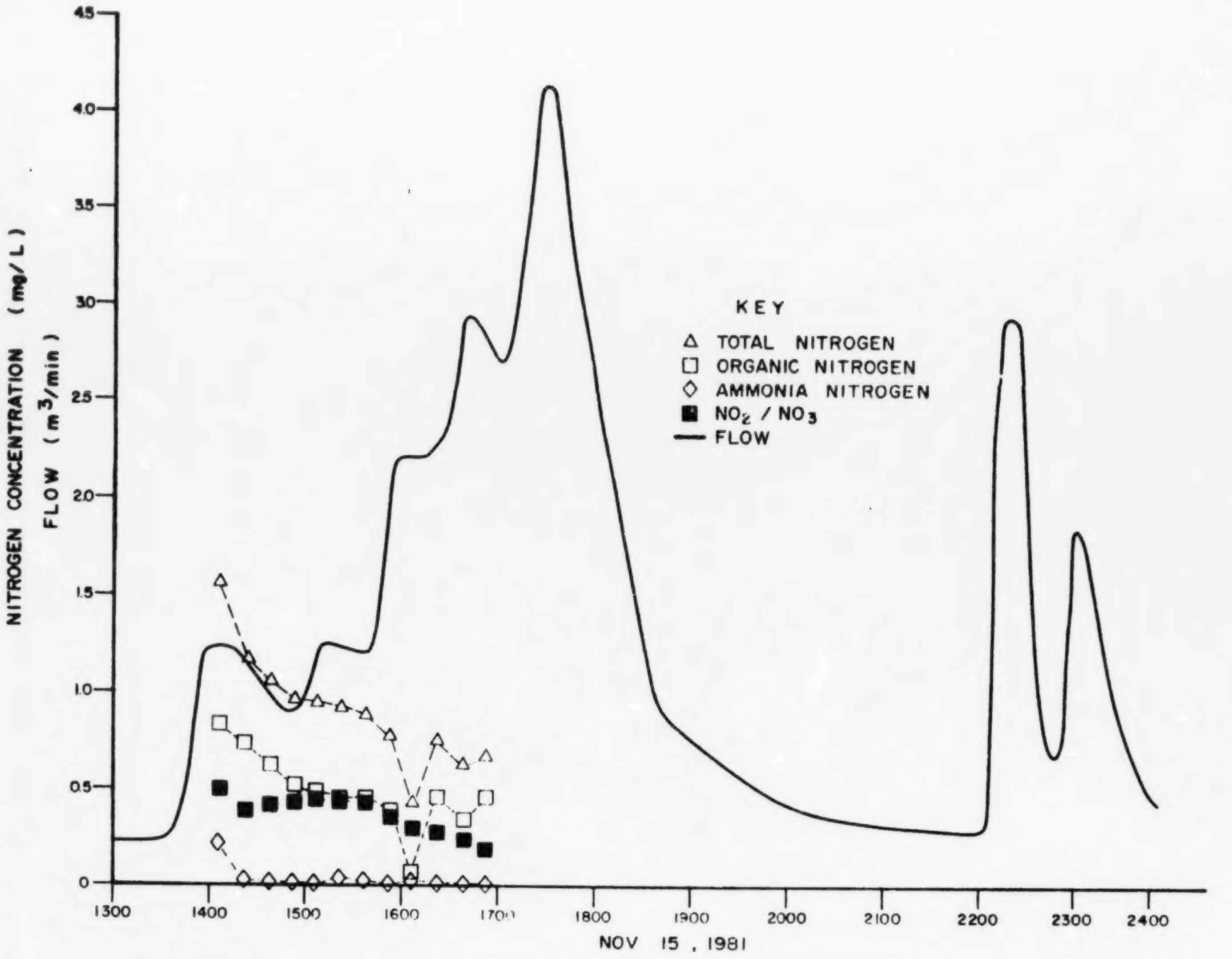


FIGURE 6 (Continued). FLUCTUATIONS IN CONCENTRATIONS OF SELECTED PARAMETERS IN STORMWATER RUNOFF FOR THE FIRST THREE HOURS OF A LARGE STORM EVENT

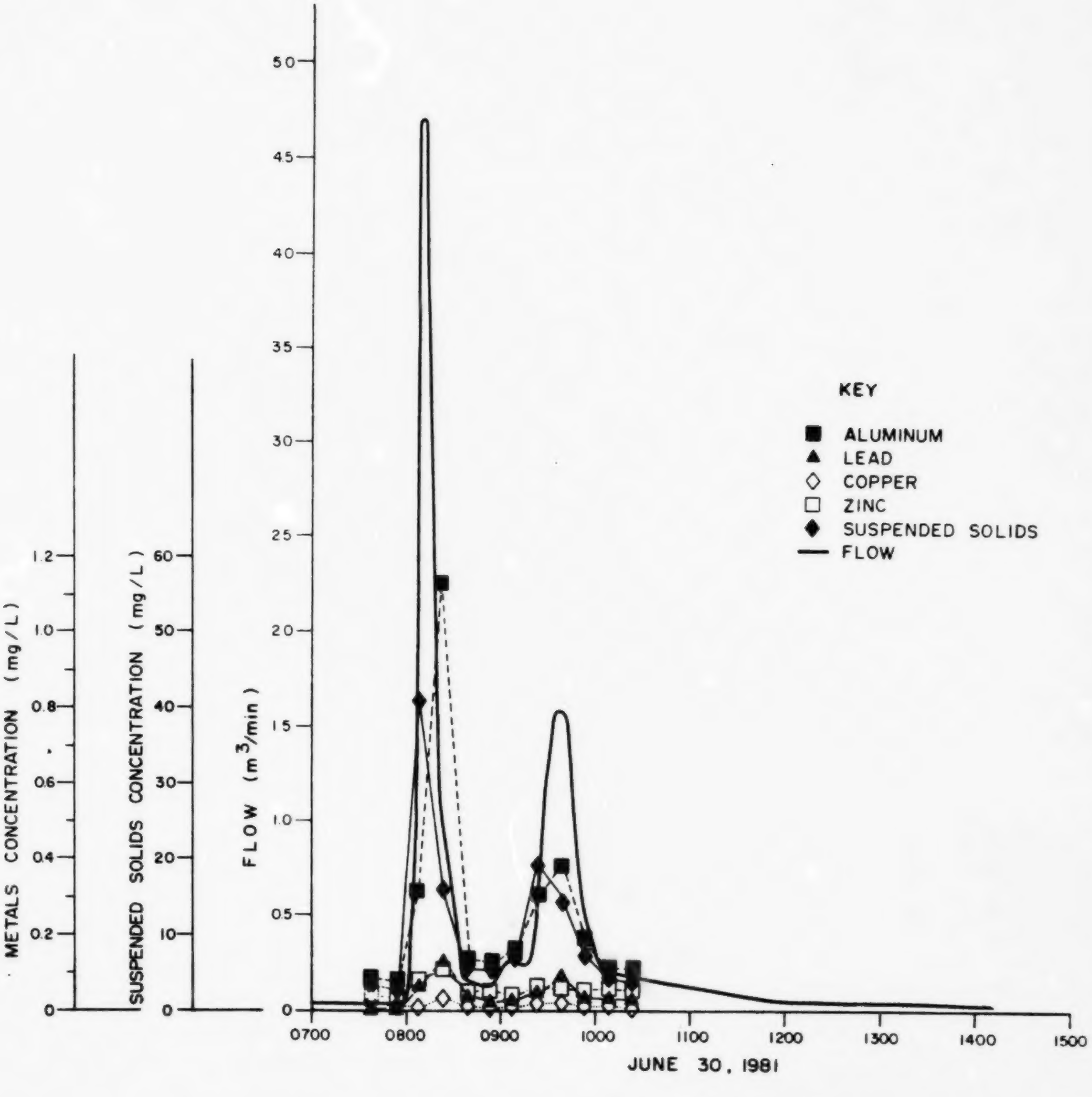


FIGURE 7 . FLUCTUATIONS IN CONCENTRATIONS OF SELECTED PARAMETERS IN STORMWATER FOR AN ENTIRE STORM

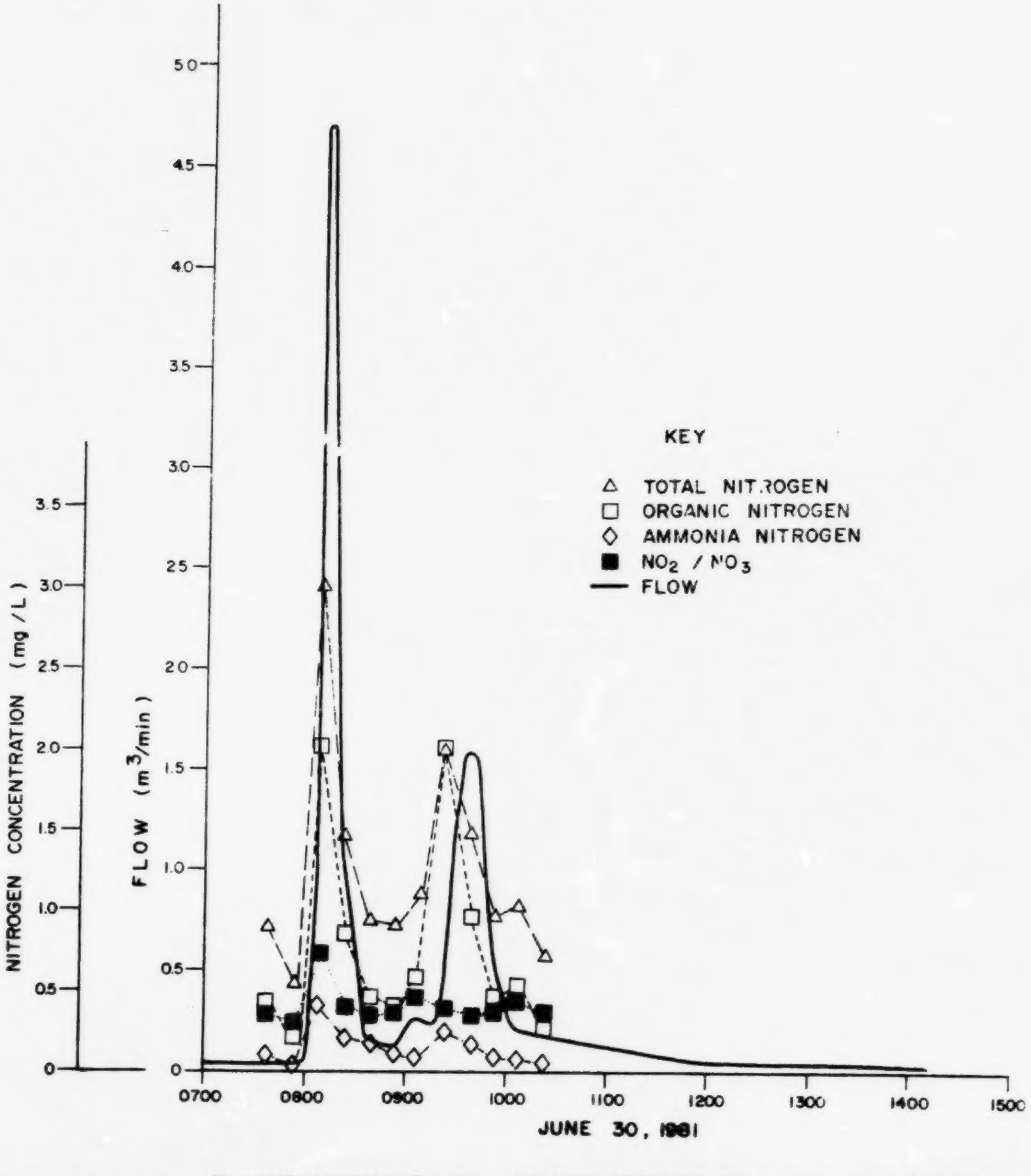


FIGURE 7 (Continued). **FLUCTUATIONS IN CONCENTRATIONS OF SELECTED PARAMETERS IN STORMWATER FOR AN ENTIRE STORM**

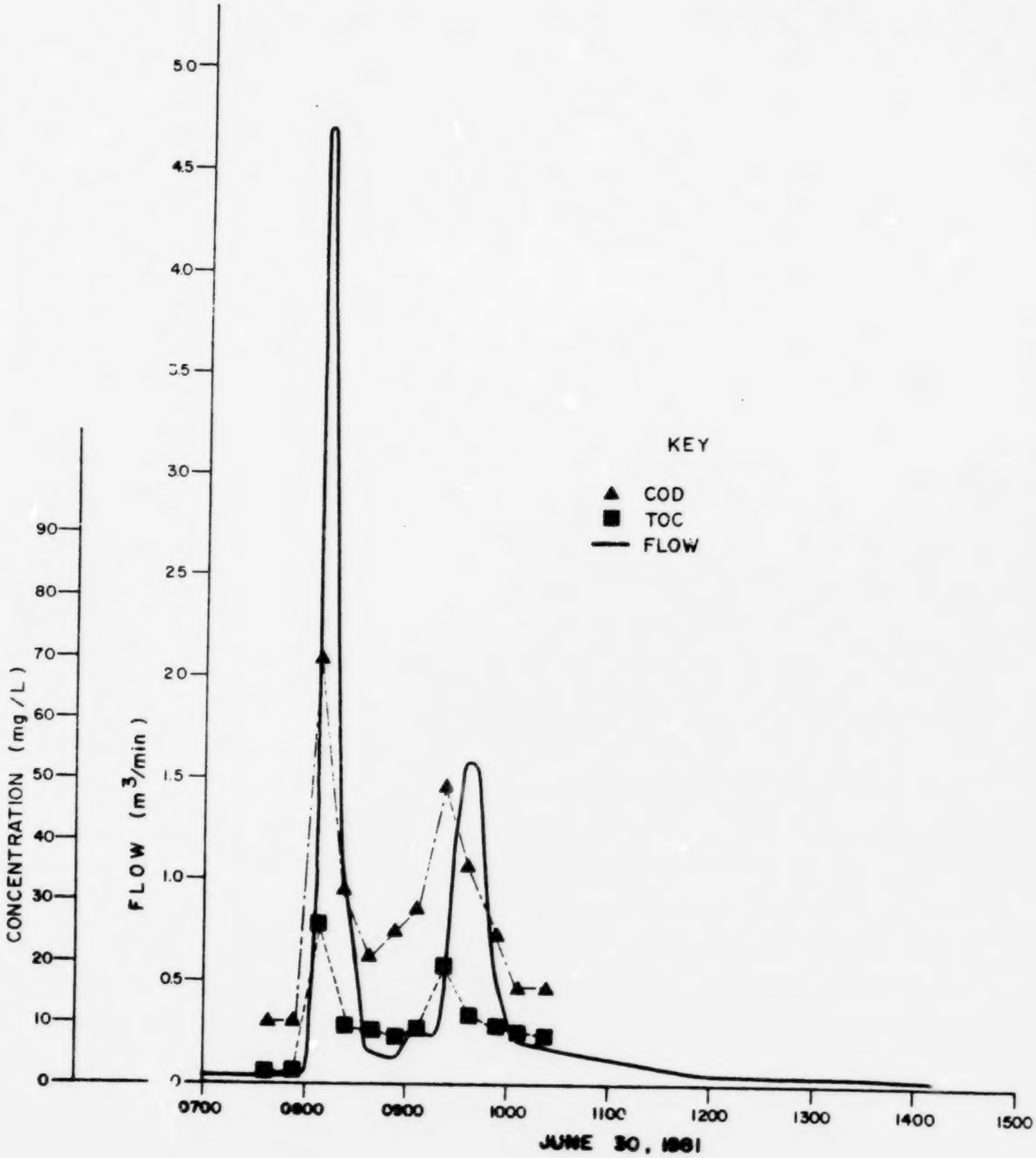


FIGURE 7 (Continued). FLUCTUATIONS IN CONCENTRATIONS OF SELECTED PARAMETERS IN STORMWATER FOR AN ENTIRE STORM

where: C_{FA} = flow-weighted mean concentration

Li = loading at time "i"

Fi = flow at time "i"

7.2.1 BACTERIOLOGICAL DATA

Bacteriological samples were collected in sterilized glass containers. Grab samples were collected, generally every 15 minutes for a 3-hour duration during a storm.

The median fecal coliform value during dry weather was 700 MPN/100 mL, while it was 2400 MPN/100 mL during wet weather. Ferguson and Hall had assumed a fecal coliform value of 11 000 MPN/100 mL(3). The calculated flow-weighted mean value for Ontario Great Lakes communities discharging surface runoff was 5000 MPN/100 mL(19). The mean value for an Australian residential catchment area was 7600 MPN/100 mL (range from 100 to 110 000 MPN/100 mL)(48).

The median total coliform value during both dry weather and wet weather was 9200 MPN/100 mL. Ferguson and Hall had assumed a total coliform concentration of 100 000 MPN/100 mL(3). The calculated flow-weighted mean value for Ontario Great Lake communities discharging surface runoff was 20 000 MPN/100 mL(19). These values compare to a range of monthly mean values for the Annacis STP from 841 MPN/100 mL to 9 169 100 MPN/100 mL(27). The value depended upon whether disinfection of the effluent was taking place. This indicates stormwater is a particularly significant source of total coliform when effluents from the sewage treatment plants are being disinfected.

The higher coliform values reported in the literature likely arise from two possible situations. One of these is carrying out a study where there are sewer cross connections. More likely however, is that literature values reflect conditions for catchment areas where considerably less rainfall occurs than in the Vancouver area. Although there may be equal loadings per unit area, the concentrations in Vancouver are much lower due to high precipitation volumes.

Table 20 details trends of bacteriological values through individual storms. Both the total and fecal coliform values appeared to follow peaks and valleys associated with the flow. Since values for suspended solids also followed this trend, the higher coliform values during high flow may have been caused by association of coliform with suspended solids.

7.2.2 CARBON

Samples for total organic and inorganic carbon were collected in a manner similar to that described for metals (7.2.3 below). Samples were not preserved, but were kept cool, and out of contact with air. Samples were collected during both wet and dry weather flow conditions.

Mean inorganic carbon values were 9.2 mg/L during dry weather, and 3.6 mg/L during wet weather. Mean total organic carbon (TOC) values were 12.1 mg/L during dry weather, and 10.1 mg/L during wet weather. The flow-weighted dry weather mean value was 20.3 mg/L (in summary at end of Table 12). The flow-weighted wet weather mean value was 7.52 mg/L (in summary at end of Table 13). Data combined from two Australian residential catchment areas had a mean value of 26.6 mg/L(48).

A description of trends during storms which were monitored, in Table 20, indicates that TOC values followed flow in 12 cases but that in 10 other cases, showed no trend.

The TOC loading during dry weather (Table 12) ranged from 0.001 kg to 0.264 kg over a 15 minute interval, or 0.096 kg/d to 25.3 kg/d for the catchment area. The mean value was 0.037 kg/15 minutes, representing a loading of 3.6 kg/d. The TOC loading during wet weather (Table 13) ranged from 0.001 kg to 3.864 kg over a 15 minute period, or from 0.096 kg/d to

371/kg/d. The mean value was 0.199 kg/15 minutes, representing a loading of 19 kg/d.

7.2.3 METALS

Samples normally were collected about every 3.75 minutes, with each group of 4 samples making a 15 minute composite sample. Generally 1 1/2 hours of each storm was monitored, although longer time intervals were used when long heavy rainfalls were encountered. For such situations, samples were collected every 30 minutes, with each group of 4 samples making a 2-hour composite sample. Samples for metals analysis were preserved using 2 mL of concentrated nitric acid (HNO_3) per 500 mL of sample collected except for mercury. These were preserved by lowering the pH to 2, using sulphuric acid (H_2SO_4).

7.2.3.1 Aluminum

This metal was measured during periods of dry and wet weather flows, in the dissolved and total form. The mean values for total aluminum were 0.39 mg/L during dry weather and 0.43 mg/L during wet weather. The flow-weighted dry weather mean value was 0.61 mg/L (in summary at end of Table 12), but the wet weather mean value was 0.48 mg/L (in summary at end of Table 13). An examination of the total aluminum data in Table 20 indicates that in general, total aluminum followed the peaks and valleys associated with flow. Since values for suspended solids also followed this trend, total aluminum was probably associated with suspended solids. The data in Table 11 tends to confirm the presence of insoluble aluminum because total aluminum is about three times the concentration of dissolved aluminum.

The mean values for dissolved aluminum were 0.08 mg/L during dry weather and 0.03 mg/L during wet weather. The mean value for dissolved aluminum was less in wet weather than in dry weather, probably because of dilution during periods of high flow. This contradicts the trend noted for total aluminum. Aluminum was not measured in the precipitation samples

(Table 4), therefore the direct input of aluminum to stormwater from precipitation cannot be determined.

The loading of total aluminum during dry weather (Table 12) ranged from 0.00005 kg to 0.01033 kg over a 15-minute interval, or 0.0048 kg/d to 0.99 kg/d. The mean value was 0.00112 kg/15 minutes, representing a loading 0.108 kg/d. The loading of total aluminum during wet weather (in summary at end of Table 13) ranged as high as 0.787 kg during a 15-minute interval or 75.6 kg/d. The mean loading for all monitored storms was 0.013 kg during a 15-minute interval, or 1.21 kg/d for the catchment area. This is the largest loading of any metal in Table 13.

7.2.3.2 Cadmium

Cadmium was not analyzed in any dry weather samples collected. The median total cadmium wet-weather value was <0.01 mg/L. Data combined from two Australian residential catchment areas had a mean value of 0.01 mg/L(48).

The ninetieth percentile value for cadmium in the lower Fraser River from the Fraser River Estuary Study was 0.001 mg/L(30). The high detection limit used in our analysis does not permit interpretation of the effect of cadmium in stormwater on Fraser River water quality.

7.2.3.3 Chromium

Samples were not collected during dry weather flow conditions for the analysis of chromium. Nine samples, collected during wet weather, had a median value of <0.01 mg/L. Data combined from two Australian residential catchment areas had a mean value of 0.022 mg/L.

The 95th percentile value for chromium in the lower Fraser River from the Fraser River Estuary Study was <0.005 mg/L(30). The varying detection limits do not permit interpretation of the effect of chromium in stormwater on Fraser River water quality.

7.2.3.4 Copper

This metal was measured as dissolved and total during dry and wet weather flow conditions. The mean total copper values were 0.04 mg/L during dry weather and 0.037 mg/L during wet weather. The flow-weighted mean value was 0.04 mg/L during dry weather (in summary at end of Table 12) and 0.038 mg/L during wet weather (in summary at end of Table 13). Ferguson and Hall had based their loadings on copper concentrations of 0.01 mg/L(3). Data combined from two Australian residential catchment areas had a mean value of 0.063 mg/L. These compare to a median value of 0.005 mg/L found in the lower Fraser River waters(30). Thus the actual observed concentrations are four times the concentrations predicted, and about eight times the value in the Fraser River.

An examination of the total copper data in Table 20 indicates that in general, total copper followed the peaks and valleys associated with flow. Since values for suspended solids also followed this trend, total copper was probably associated with suspended solids. This is confirmed by the data in Table 11 which shows that most of the copper was in the undissolved form.

Dissolved copper during dry weather flow had a mean value of 0.03 mg/L and during wet weather flow a mean value of 0.007 mg/L. Significant dilutions are available to dissolved copper during periods of high flow. This apparently contradicts the trend noted for total copper where mean values were approximately the same in dry and wet weather. Although values of total copper measured in precipitation ranged from <0.001 mg/L to 0.100 mg/L at the three sites (see Table 4), the mean value was only 0.009 mg/L. The median dissolved copper value in the lower Fraser River from the Fraser River Estuary Study was 0.002 mg/L(30). The mean concentration in stormwater is only about three times this latter concentration, and therefore dissolved copper does not impact considerably on the river water quality.

The loading of total copper during dry weather (Table 12) ranged as high as 0.00033 kg over a 15-minute interval. The mean value was 0.00007 kg/15 minutes, or 0.007 kg/d. The loading of total copper during wet weather (Table 13) was as high as 0.019 kg during a 15-minute interval on August 25, or 1.8 kg/d. The mean loading for all monitored storms during a 15-minute interval was 0.0007 kg, or 0.071 kg/d from the catchment area. The loading of copper is less than that of aluminum, lead, or zinc.

7.2.3.5 Iron

Iron was measured only during wet weather. Total iron had a mean value of 0.92 mg/L. Dissolved iron had a mean value of 0.022 mg/L. The median total iron concentration in Fraser River waters within the Fraser River Estuary Study area was 1.0 mg/L(30). Thus the iron concentrations in stormwater would not impact on the river.

7.2.3.6 Lead

This metal was measured as total and dissolved during dry and wet weather. The mean total lead value was 0.02 mg/L during dry weather and 0.071 mg/L during wet weather. The flow-weighted mean value was 0.04 mg/L during dry weather (in summary at end of Table 12), and 0.059 mg/L during wet weather (in summary at end of Table 13). Ferguson and Hall had made their predictions on the basis of a lead concentration of 0.061 mg/L(3). Data combined from two Australian residential catchment areas had a mean value of 0.4 mg/L. These values are about thirty times the ninetieth percentile value of 0.002 mg/L found in the lower Fraser River from the Fraser River Estuary Study(30). Thus the observed mean values were about the same as predicted, and lend in stormwater would have a certain impact on the water quality of the river.

An examination of the total lead data in Table 20 indicates that in general, total lead followed the peaks and valleys associated with flow. Since values for suspended solids also followed this trend, total lead values were associated with suspended solids.

Mean dissolved lead values were 0.02 mg/L during dry weather and 0.009 mg/L during wet weather. Significant dilutions were available to the dissolved lead fraction during wet weather flow conditions. Values of total lead measured in precipitation ranged from 0.001 mg/L to 0.500 mg/L at the three sites (Table 4), with a mean value of 0.037 mg/L. This is of the same order as in the stormwater, indicating that the rain washes lead out of the air.

The loading of total lead during dry weather flow conditions (Table 12) was as high as 0.0009 kg over a 15-minute interval. The mean value was 0.00007 kg/15 minutes or 0.007 kg/d.

The loading of total lead during wet weather (Table 13) was as high as 0.0903 kg during a 15-minute interval or 8.7 kg/d. The mean loading for all monitored storms during a 15-minute interval was 0.0017 kg, or 0.164 kg/d from the catchment area. This is the third largest loading of a metal to the river from stormwater.

7.2.3.7 Manganese

This metal was measured as total and dissolved during both wet and dry weather flows. The mean total manganese value was 0.07 mg/L during dry weather and 0.04 mg/L during wet weather. The mean dissolved value during dry weather was 0.08 mg/L. The results imply that all the manganese present during dry weather was in the dissolved form. These mean values compare to the median value of 0.035 mg/L reported for waters of the lower Fraser River from the Fraser River Estuary Study area(30). Thus stormwater will not affect manganese values in the river appreciably.

7.2.3.8 Mercury

Total mercury was measured on nine occasions during wet flow conditions, and the mean value was 0.00009 mg/L. Values reported for an Australian residential catchment area were all 0.0001 mg/L(48). The median reported value for the Fraser River Estuary Study area was 0.00005 mg/L(30). Thus the stormwater is probably not a significant source of mercury to the river.

7.2.3.9 Molybdenum

Total molybdenum was measured only during wet weather flow conditions on nine occasions and the median value was <0.01 mg/L. The median value in the lower Fraser River from the Fraser River Estuary Study was 0.0007 mg/L(30). The high detection limits used in our study do not permit an interpretation of the data.

7.2.3.10 Nickel

Nine samples collected during wet weather flow conditions were analyzed for total nickel, however it was not detectable (<0.05 mg/L). Data for total nickel in precipitation in Table 4 indicate that the highest nickel concentration recorded was 0.03 mg/L. Data combined from two Australian residential catchment areas had a mean value of 0.022 mg/L. Nickel in the lower Fraser River from the Fraser River Estuary Study was usually below the detection limit of 0.01 mg/L(30). Since nickel could not be detected in the stormwater, and was at low levels in precipitation, stormwater is not a significant source of nickel to the river.

7.2.3.11 Zinc

This metal was measured in the total and dissolved state during dry and wet weather flow conditions. The mean total zinc value was 0.086 mg/L during dry weather, and 0.12 mg/L during wet weather. The flow-weighted mean value was 0.096 mg/L during dry weather (in summary at end of Table 12) and 0.123 mg/L during wet weather (in summary at end of Table 13). Ferguson and Hall had assumed a value of 0.008 mg/L as the basis of their predicted zinc loadings from residential catchment areas(3). Actual mean values were about fifteen times this assumed value.

Data combined from two Australian residential catchments had a mean value of 0.95 mg/L. These mean values compare to a median value of 0.008 mg/L in the lower Fraser River from the Fraser River Estuary Study area(30). Thus stormwater concentrations of total zinc are about fifteen times greater than concentrations found in the Fraser River.

An examination of the total zinc data in Table 20 indicates that in general, total zinc followed the peaks and valleys associated with flow. Since values for suspended solids also followed this trend, total zinc values were associated with suspended solids.

Mean dissolved zinc values were 0.1 mg/L for dry weather flows, and 0.08 mg/L for wet weather flows. The median dissolved zinc value for the lower Fraser River is 0.005 mg/L. As was the case for total zinc, stormwater concentrations of dissolved zinc were about fifteen times greater than the concentrations found in the Fraser River.

A comparison with values for total zinc suggests that much of the zinc for dry weather flows was in the dissolved state. Although values of total zinc measured in precipitation ranged from <0.005 mg/L to 1.10 mg/L at the three sites (Table 4), the mean value was only 0.056 mg/L. Rainfall could still be a significant source of zinc in the stormwater.

The loading of total zinc during dry weather (Table 12) ranged from 0.00001 kg to 0.00107 kg over a 15-minute interval. The mean value was 0.00018 kg, or 0.017 kg/d. The loading of total zinc during wet weather (Table 13) was as high as 0.0829 kg during a 15-minute interval or 7.96 kg/d. The mean loading for all monitored storms during a 15-minute time interval was 0.0027 kg, or 0.26 kg/d from the catchment area. This is the second largest metal loading from stormwater. This fact, in combination with the large number of stormwater and combined sewer overflows along the North Arm of the Fraser River, indicates that stormwater may contribute to the increased zinc values noted in that river section by Drinnan and Clark(30).

7.2.4 NITROGEN

Nitrogen can exist in several forms. These include organic, nitrate, nitrite, and ammonia. The different forms of nitrogen can vary in time depending upon oxidation, reduction, and in the case of organic nitrogen, decay processes.

Samples for nitrogen were collected in the same manner as for metals, described in Section 7.2.3. However, the samples were not preserved but were analyzed shortly after collection.

7.2.4.1 Ammonia Nitrogen

Ammonia (N) had a mean value of 0.214 mg/L during dry weather (Table 10) and a mean value of 0.172 mg/L during wet weather. This compares to a mean value of about 15 mg/L (based on only 12 values) being discharged from the Iona and Annacis Island STP's. Thus the impact of stormwater relative to effluent from the sewage treatment plants would be minimal.

Data combined for two Australian residential catchment areas had a mean value of 0.40 mg/L, which is about twice the values found in Vancouver. The median value in the lower Fraser River from the Fraser River Estuary Study was <0.05 mg/L(30). Ammonia (N), in general, did not follow trends apparent in the flow data (Table 20), a result to be expected since it is in a dissolved state.

7.2.4.2 Kjeldahl Nitrogen

Kjeldahl nitrogen is the sum of organic and ammonia nitrogen. The mean value for Kjeldahl nitrogen during dry weather was 1.34 mg/L (Table 10), and 1.07 mg/L during wet weather. Cain and Swain have indicated mean Kjeldahl nitrogen values in excess of 20 mg/L yearly from 1976 to 1977 at the Annacis STP(27). Thus concentrations in stormwater are considerably smaller than in effluents from sewage treatment plants.

Data combined from two Australian residential catchment areas yielded a mean value of 2.57 mg/L, about twice the value found in Vancouver. The median organic nitrogen value in the lower Fraser River from the Fraser River Estuary Study area was 0.14 mg/L(30). Thus median Kjeldahl nitrogen values could be from 0.14 mg/L to about 0.18 mg/L. Mean stormwater values are only five to seven times this, and would impact on the river water quality to an even lesser extent than effluents from the sewage treatment plants. In general, Kjeldahl nitrogen did not follow flow trends (Table 20), indicating it is in a dissolved state.

7.2.4.3 Nitrate/Nitrite Nitrogen

Due to the dominance of nitrate, these nitrogen forms are analyzed and reported as one value. Mean values for nitrate/nitrite were 1.11 mg/L during dry weather (Table 10) and 0.54 mg/L during wet weather (Table 11). Nitrate data combined from two Australian residential catchment areas had a mean value of 5.9 mg/L, while nitrite had a mean value of 0.055 mg/L. The values for the Australian catchments are about ten times those recorded in Vancouver.

The median lower Fraser River nitrate value from the Fraser River Estuary Study was 0.081 mg/L(30). This is only about one-sixth the value in stormwater. Thus stormwater would have little impact on the river water quality. In general nitrate/nitrite values did not follow flow trends (Table 20).

7.2.4.4 Total Nitrogen

Mean values for total nitrogen were 2.41 mg/L during dry weather flow conditions and 1.61 mg/L during wet weather flow conditions. The flow-weighted mean value was 2.6 mg/L during dry weather (in summary at end of Table 12) and 1.55 mg/L during wet weather (in summary at end of Table 13). Ferguson and Hall had assumed a total nitrogen concentration of 2 mg/L as the basis of their predicted loadings from residential catchment areas(3). This value is about twenty percent higher than actually found.

Values indicated as being typical from stormwater runoff in Ontario had a mean value of 3.5 mg/L(18), about twice the value recorded for Vancouver. In general, total nitrogen and its many forms did not follow flow trends (Table 20).

Loadings of total nitrogen ranged from 0.0007 kg to 0.0246 kg during dry weather (Table 12) over a 15-minute interval. The mean value was 0.0048 kg, or 0.46 kg/d. The loading of total nitrogen during wet weather (Table 13) ranged from 0.0003 kg to 0.3770 kg during a 15 minute interval. The maximum value represented a maximum loading of 36 kg/d. The mean loading for all monitored storms during a 15-minute interval was 0.0328 kg, or 3.15 kg/d from the catchment area.

7.2.5 OIL AND GREASE

Oil and grease grab samples were collected in glass bottles. Generally samples were collected every 15 minutes for either a 1 1/2 or 3-hour duration. Samples were preserved using 3 mL of concentrated hydrochloric acid (HCl).

Values for oil and grease provide an indication of the amount of petroleum products washed off the streets. In general, concentrations of oil and grease followed flows, where trends were noted (Table 20). Mean values were

3.3 mg/L during dry weather and 3 mg/L during wet weather. The fact that approximately the same mean value for oil and grease occurred during both dry and wet weather flows indicates that during high wet weather flows, significant loadings of oil and grease were washed off road surfaces. This assumes that the oil and grease is uniformly distributed throughout the stormwater, which is not necessarily true.

7.2.6 OXYGEN DEMANDING SUBSTANCES

Samples for oxygen demanding substances were collected in the same manner as for metals, described in Section 7.2.3. However, samples collected for BOD_5 analyses were not preserved, but were kept cool until submitted to the laboratory (maximum 12 hours), and out of contact with air. Samples collected for COD analyses were preserved using 0.2 mL of H_2SO_4 per 250 mL. Information provided in Section 2.5 indicates that BOD_5 measurements may not be suitable for providing estimates of oxygen demanding potential of stormwater, and that COD may provide better estimates.

Values for BOD_5 were measured during the early stages of the monitoring programme. Mean values were <10 mg/L during dry weather flow conditions (Table 10 and 11). Ferguson and Hall had assumed a BOD_5 concentration of 29 mg/L as the basis of their predicted loadings from residential catchment areas(3). Ontario has used a mean BOD_5 value for stormwater runoff of 14 mg/L(18). The mean value for two Australian residential catchment areas was 14 mg/L.

Mean COD values were 38.4 mg/L (Table 10) during dry weather and 33.2 mg/L (Table 11) during wet weather. The flow-weighted mean value was 67.8 mg/L during dry weather (in summary at end of Table 12) and 24.6 mg/L during wet weather (in summary at end of Table 13). The mean value for COD discharged from the Annacis STP during 1979 was 293 mg/L(27).

Data for COD indicate that in general, concentrations tended to increase with increased flows. Since concentrations of suspended solids tended to follow flow fluctuations, COD values were likely associated with suspended solids.

The loading of COD during dry weather ranged from <0.007 kg to 0.864 kg (Table 12) over a 15-minute interval. The mean loading was 0.125 kg, or 12 kg/d. The COD loading during wet weather was as high as 12.4 kg (Table 13) over a 15-minute interval or 1192 kg/d. The mean loading for all monitored storms during a 15-minute interval was 0.659 kg, or 63.2 kg/d from the catchment area.

7.2.7 pH

Samples for pH were collected in the same manner as those for metals, described in Section 7.2.3. However, the samples were not preserved.

The pH of stormwater runoff is a factor in predicting impacts on the receiving water, and provides an indication of how precipitation is buffered within the catchment area.

The pH of runoff during dry weather flow conditions ranged from 6 to 7.7 (Table 10), with a median value of 7.3. During wet weather, the pH ranged from 5.6 to 7.5 (Table 11), with a median value of 6.7. Since the pH in the precipitation ranged from about 4 to 7.3 (Table 4a), with a median value of about 4.85, it is evident that the catchment area is buffering the more acidic rainfalls. However, this buffering action is diminished during wet weather flow conditions, possibly due to less contact time with minerals in the soil. However the stormwater does retain some residual buffering capacity.

7.2.8 PESTICIDES

Grab samples for pesticide analysis were collected using special bottles provided by the Environmental Laboratory.

Six pesticides were analyzed for in the Spring of 1981 in water samples collected during dry weather flows. The reason that the pesticides were examined in dry weather flows as opposed to wet weather flows was that detection limits for pesticides were considered too high to permit an analysis at times when high flows would dilute any pesticide in the water. The six pesticides examined were considered by personnel of the B.C. Ministry of Environment Pesticide Control Branch to be in most common use in residential areas. These pesticides included 2,4-D, captan, diazinon, dicamba, mecoprop, and methoxychlor. None were detected in the samples (Table 10), possibly because some rain may be needed to wash pesticide residues into the storm sewer.

7.2.9 ARSENIC

Only one sample was analyzed for total arsenic during dry weather conditions, and arsenic could not be detected (<0.005 mg/L). Nine samples were analyzed for total arsenic during wet weather, with values ranging from <0.05 mg/L to 0.06 mg/L. The median value was <0.05 mg/L.

7.2.10 PHENOLICS

Samples for phenolic analysis were collected in the same manner as those for metals, described in Section 7.2.3.

Mean values for phenols were 0.037 mg/L during dry weather (Table 10) and 0.013 mg/L (Table 11) during wet weather. This would indicate that the phenolic concentrations were reduced with increased flows.

The median phenolic concentration in the lower Fraser River from the Fraser River Estuary Study was <0.01 mg/L(30). The concentration of phenolics in stormwater is probably not significant relative to the concentrations in the river.

7.2.11 PHOSPHORUS

Samples collected for the measurement of phosphorus were collected in the same manner as those for the measurement of metals, described in Section 7.2.3. However, the samples were not preserved but were kept cool and were usually analyzed within about 12 hours.

Total phosphorus had a mean value of 0.067 mg/L during dry weather compared to a mean value of 0.089 mg/L during wet weather flow conditions. The flow-weighted mean value was 0.17 mg/L during dry weather (in summary at end of Table 12) and 0.161 mg/L during wet weather (in summary at end of Table 13).

The Province of Ontario has indicated that total phosphorus in stormwater runoff has a mean value of 0.35 mg/L(18). Data combined from two Australian residential catchment areas had a mean value of 0.35 mg/L. The median total phosphorus value for the lower Fraser River from the Fraser River Estuary Study ranged from 0.04 mg/L to 0.1 mg/L, depending upon location in the river(30). Thus stormwater concentrations are not significant compared to concentrations of phosphorus already in the river.

Loadings of total phosphorus during dry weather ranged from 0.00002 kg to 0.00258 kg (Table 12) over a 15-minute interval. The mean loading rate was 0.00031 kg, or 0.03 kg/d. The total phosphorus loading rate during wet weather flow conditions ranged as high as 0.0518 kg (Table 13), or 5 kg/d. The mean loading rate for all monitored storms during a 15-minute interval was 0.0041 kg, or 0.396 kg/d from the catchment area.

7.2.12 POLYCHLORINATED BIPHENYLS

Grab samples for the measurement of polychlorinated biphenyls were collected using special bottles provided by the Environmental Laboratory.

Polychlorinated biphenyls were measured randomly throughout the study during both dry and wet weather flow conditions. Values for dry weather flows did not exceed the detection limit of 0.002 mg/L, while values for wet weather flows did not exceed the detection limit of 0.0004 mg/L. The more sensitive detection limits were possible with the collection of larger quantities of sample.

7.2.13 SOLIDS

Samples for the measurement of solids and specific conductance were collected in the same manner as those for the measurement of metals, described in Section 7.2.3. However, samples were not preserved.

7.2.13.1 Specific Conductance

Specific conductance indicates the quantity of dissolved solids present in the stormwater runoff. The mean specific conductance value for dry weather flows was 103 µS/cm, and 52 µS/cm during wet weather. This lower mean value during wet weather indicates that large wet weather volumes diluted the dissolved solids present. This was also evident from the analysis of dissolved metals (Section 7.2.3). Values within the lower Fraser River in waters unaffected by sea water ranged from 99 µS/cm to 150 µS/cm(30). Thus dissolved solids in stormwater would have no significant effect on the river water quality.

7.2.13.2 Suspended Solids

Fixed suspended solids indicate the amount of inorganic matter present in the suspended solids fraction. The mean value during dry weather was 7.7

mg/L (Table 10), while during wet weather the mean value was 11 mg/L (Table 11). The higher inorganic solids values during wet weather flow conditions were likely associated with larger quantities of grit which were washed into the collection system during these times, and which remained in suspension.

Total suspended solids had a mean value during dry weather flows of 13.6 mg/L (Table 10), and 19.8 mg/L during wet weather flow conditions (Table 11). The flow-weighted mean value during dry weather was 25.9 mg/L (in summary at end of Table 12) and 22.8 mg/L during wet weather flows (in summary at end of Table 13). Flow-weighted mean values during dry weather for most other parameters discussed (phosphorus, nitrogen, COD, aluminum, lead, zinc) were higher than simple mean values, possibly due to the extremely low flows used in the calculation of the flow-weighted mean value. The higher simple mean value for wet weather flows indicates that as expected, great quantities of solids became suspended during rainfalls, after being washed off road surfaces. The data for most storms indicate that in general, suspended solids values fluctuated according to the flow rate (Table 20).

Ferguson and Hall had used a suspended solids concentration of 33 mg/L as being representative of dry weather flow concentrations(3). Actual recorded values were slightly less than this.

Ontario has indicated an expected mean total suspended solids value of 170 mg/L(18). Data combined from two Australian residential catchment areas had a mean value of 183 mg/L.

Loadings of suspended solids during dry weather ranged from 0.001 kg to 0.353 kg during a 15-minute interval, with a mean value of 0.048 kg or 4.6 kg/d. Loadings of suspended solids during wet weather ranged from 0.002 kg to 13.78 kg (Table 13), over a 15-minute interval. The maximum loading is equivalent to about 1320 kg/d. The mean loading rate for all monitored storms during a 15-minute interval was 0.463 kg, or 44.5 kg/d from the catchment area.

Total suspended solids in the stormwater were made up of approximately half organic suspended solids, and half inorganic suspended solids. This is based upon mean values. Cain and Swain reported mean suspended solids values from 50 mg/L to 80 mg/L at Annacis and Lulu STP's(27). Most of these solids were likely organic. Therefore concentrations of organic suspended solids in stormwater are one-fifth to one-eighth those in sewage effluents.

7.2.13.3 Grit and Sediment

Accumulated grit and sediment which settled out in the flume was regularly cleaned out. On four occasions, samples of the grit and sediment were collected for analysis. The data have been reported in Table 17. The grit and sediment had accumulated in the flume for periods varying from eight to twenty-two days.

Aluminum was measured twice in the grit and sediment, with a mean value of 6.31 mg/g as dry-weight. Cadmium was also measured twice, with one value not being detectable (<1 µg/g as dry-weight) and one value of 19 µg/g as dry-weight. Stancil has reported cadmium levels in the sediments of back-waters of the Fraser River at New Westminster in the range from <1 to 19 µg/g as dry-weight(29). This area of New westminster is in close proximity to a number of storm drains and combined sewer overflows(3).

The mean copper value of 25.5 µg/g was typical of copper values reported by Stancil(29) for sediments in backwaters of the Fraser River. Stancil reported mean values for copper in the sediments of the Main Arm from 18 to 26 µg/g on a dry-weight basis(29). Less industrialized areas such as the Serpentine River, Nicomekl River and rivers in the Quesnel-Chilcotin region had sediments which ranged from 10 µg/g to 20 µg/g(49). Thus copper in stormwater sediments will likely not affect the sediments of the Fraser River. This result differs from that found for the water chemistry.

Iron had a mean value of 12.4 mg/g. This value is of the same order of magnitude as reported by Stancil for sediments in the Main Arm of the Fraser River, and considerably less than reported for backwaters(29). Values in sediments from less industrialized areas such as the Quesnel-Chilcotin region, Upper Fraser River, Serpentine and Nicomekl rivers ranged from 1 mg/g to 2 mg/g(40).

Lead had a mean value of 180 µg/g. This value is considerably higher than any reported by Stancil for Main Arm Fraser River or backwater sediments(29). The only sediments reported by Stancil with lead values in the same order of magnitude were associated with the Brunette Basin(29), a basin receiving inflow from a considerable number of stormwater outfalls(3). Lead values in sediments from rivers in the Quesnel-Chilcotin region ranged from 0.5 µg/g to 20 µg/g(49). Thus lead in stormwater sediments will affect the sediment quality of the Fraser River. This was also found with water chemistry, which showed that stormwater could be a significant source of lead.

Manganese was analyzed on only two dates, resulting in values of 195 and 210 µg/g on a dry-weight basis. These values were less than reported by Stancil for manganese in Main Arm Fraser River or backwater sediments(29).

Polychlorinated biphenyls (PCB's) were detected in the grit and sediments twice. Values ranged from <0.02 to 0.19 µg/g as dry-weight of Arochlor 1242 and from <0.02 to 0.45 µg/g as dry-weight of Arochlor 1260. Ferguson and Hall reported that PCB's in sediments in the Brunette River system ranged from 0.37 to 0.78 µg/g as dry-weight(3). These values are approximately the same as found in stormwater. Garrett has reported concentrations of polychlorinated biphenyls in sediments from the lower Fraser River, but values were related directly to a known discharge of polychlorinated biphenyls. The values ranged from being not detectable to 1500 µg/g on a dry-weight basis(47). Thus stormwater constitutes a diffuse source of PCB's at low levels to the river.

Zinc had a mean value of 140 µg/g. This value is of the same order of magnitude as reported by Stancil for sediments from the Brunette Basin(29), a basin receiving inflow from a considerable number of stormwater outfalls(3). This value is also considerably higher than found in Fraser River sediments(29), or sediments from the Quesnel-Chilcotin region, the Upper Fraser River, or the Nicomekl River (20 µg/g to 50 µg/g)(49). Thus zinc in stormwater sediments will affect the sediment quality of the Fraser River. This was also found with water chemistry, which showed that stormwater could be a significant source of zinc.

The Student's "t test" was used to assess the relationship between individual metals and polychlorinated biphenyl values in the sediments, between metals and polychlorinated biphenyl values and the total flow through the flume since it was last cleaned of sediment, and between metals and polychlorinated biphenyl values and the number of antecedent dry days. Only those relationships which were significant at the 0.05 level of probability are reported below.

Lead and zinc were significantly related ($t=1.7396$, $P=0.1326$) as were the polychlorinated biphenyls Arochlor 1242 and Arochlor 1260 ($t=-0.6229$, $P=0.0512$). Lead and zinc were each significantly related to the total flow through the flume since the last cleaning (For lead: $t=-2.4292$, $P=0.512$; for zinc: $t=-2.4452$, $P=0.0501$). Iron was significantly related with the number of antecedent dry days ($t=0.377$, $P=0.9712$).

7.2.14 TOXICITY

7.2.14.1 Fish Bioassays

The acute toxicity of the stormwater was measured during both dry and wet weather flow conditions with static 96-hour bioassays using rainbow trout as the test species. The tests were carried out at the Environment Canada, Environmental Protection Service Environmental Toxicology Laboratory in North Vancouver, within hours of the samples being collected. Grab samples were collected every 15 minutes in special containers provided by the Laboratory. The data for these tests have been included in Table 14.

The results indicate that during both dry and wet weather flow conditions, the 96h LC50 (lethal concentration to 50% of the test species over 96 hours) was >100%. In fact, only one death occurred in all the tests, indicating that runoff from areas which are totally residential in nature is probably not acutely toxic to rainbow trout.

An attempt to carry out flow-through bioassays during the summer of 1981 proved to be unsuccessful. Cooling problems in a trailer brought to the site did not allow the test species to become acclimatized to its surroundings.

7.2.14.2 Daphnia Bioassays

Tests were conducted at the University of British Columbia during the summer of 1980, prior to the complete start-up of the monitoring program. Neonate Daphnia magna (<24 hours old), was used as the test species. The sample used in the bioassay was collected in the summer of 1980.

The results of the bioassay have been included in Table 15, while analytical results of metal concentrations in the stormwater have been included in Table 16. The data indicate that the 96h LC50 was somewhere between 32% and 56%, or approximately 37% based upon a linear interpolation between these two values. This indicates that the stormwater during dry weather may be acutely toxic to organisms lower in the food chain than fish.

The data in Table 16 indicate that the water used in the test, was of similar hardness as the mean water quality for all dry weather samples (Table 10). Although the zinc concentration was less than the mean value (0.07 mg/L in test, 0.086 mg/L in all dry weather samples), copper and lead values were appreciably higher in the test sample. The copper value was 0.154 mg/L and the lead value was 0.056 mg/L in the test sample (Table 16). The mean dry weather values were 0.043 mg/L and 0.02 mg/L respectively (Table 10).

7.3 SUMMARY OF CONCLUSIONS

The runoff coefficient predicted by Ferguson and Hall(3) of 0.45 was nearly the same as the mean coefficient of 0.40 calculated for nearly 150 storms. A multiple linear regression performed on the variables of antecedent dry weather, storm duration, average storm precipitation intensity, and maximum hourly storm intensity indicated that these factors were responsible for about 25% of the variability in the runoff coefficient.

Calculations in Appendix 1 using actual measured flows indicate that, when extrapolated over the entire lower Fraser drainage area, flows were about 45% higher than predicted by Ferguson and Hall. However, rain- fall during the same period was 37% higher than the "normal" situation on which Ferguson and Hall's predictions were based. This indicates that the predictions by Ferguson and Hall were quite accurate.

Values for several parameters tended to follow the same trends as flow during storms. These parameters included total and fecal coliform, total aluminum, total copper, total lead, and total zinc. Nitrogen, phosphorus, TOC, and COD usually showed no real trend in relation to flow.

Higher bacteriological results during stormwater runoff suggest that a great quantity of fecal matter is washed off the streets during storm events. As well, coliforms likely are associated with suspended solids in the runoff.

Analyses carried out on dry weather flow samples showed that none of the six pesticides considered to be in most common use in residential areas could be detected. Polychlorinated biphenyls could not be detected during either dry or wet weather flows in the stormwater but were present in the accumulated sediments.

Metals were analyzed as both dissolved and total. There was a trend for total aluminum, copper, lead, and zinc measured during wet weather to be usually higher or about the same as during dry weather. However, dissolved metals during wet weather were at a considerably lower concentration than during dry weather. This indicates that metals were mainly associated with suspended matter, thereby resulting in larger metal loadings during wet weather when suspended matter is entrained.

Constituents other than metals found to be at higher concentrations during wet weather than dry weather included fecal coliform, total organic carbon, total phosphorus and fixed and total suspended solids. Parameters found to be at lower concentrations during wet weather were total inorganic carbon, all forms of nitrogen, oil and grease, COD, pH, phenol and specific conductance. Lower pH values during wet weather can be attributed to the acidic nature of the precipitation and the short retention time of the water on or in the soil. This short retention time does not permit the maximum buffering effect to occur.

Concentrations of some parameters measured at the Rupert and Rosemont catchment area were less than reported in the literature for Ontario or Australian residential catchment areas. Parameters for which this was true were BOD_5, suspended solids, total organic carbon, fecal coliform, cadmium, chromium, copper, lead, nickel, zinc, mercury, total phosphorus, ammonia nitrogen, nitrate/nitrite nitrogen, and total Kjeldahl nitrogen.

Concentrations of some parameters measured at the Rupert and Rosemont catchment area were usually higher than concentrations reported in the lower Fraser River by the Fraser River Estuary Study. Parameters for which this was the case included copper, ammonia nitrogen, nitrate/nitrite nitrogen, organic nitrogen (6 to 10 times) and total phosphorus (about same), and mercury and zinc (two times higher). Values of lead in stormwater were about the same as those recorded in rainfall. Parameters at concentrations higher in the Fraser River than in the stormwater runoff included iron and manganese.

Sediments collected from the Rupert and Rosemont catchment area had similar concentrations of cadmium, copper, and iron as sediments from the Fraser River Main Arm or backwaters. However, values of lead and zinc in the Rupert and Rosemont catchment area sediments were higher, and values of manganese lower, than in sediments from the Fraser River Main Arm or backwaters.

The fact that metals in sediments are similar to background values in the river sediments, except for lead and zinc, could indicate that the only metals contributed by stormwater in any significant amounts are lead and zinc. Both these metals were found at considerably higher levels in the water column and sediments of stormwater than in the water and sediments of the river. Copper was a slight anomaly, being considerably higher when compared to the river in the water column, but not in the sediments.

PART III: INTERPRETATION OF RESULTS

8.0 DISCUSSION

8.1 STORMWATER CONTAMINANT CONCENTRATIONS

Mean concentrations used by Ferguson and Hall, the Province of Ontario, and found in this study have been summarized in Table 22. In general there would appear to be a good comparison between mean concentrations and flow-weighted mean concentrations found in this study. The values reported for Ontario are also flow-weighted mean concentrations.

8.1.1 VARIATIONS IN CONCENTRATIONS

The values for BOD_5, total nitrogen, and total phosphorus were all less in this study than those quoted by Ferguson and Hall or Ontario. Values for total and fecal coliform found in this study were less than quoted by Ferguson and Hall, while values for suspended solids were less than quoted by the Province of Ontario. Values for four metals exceeded concentrations predicted by Ferguson and Hall. These metals were copper, iron, nickel, and zinc.

A review of Ferguson and Hall's data showed that the greatest variation in quality occurred for suspended solids and coliform. The data in Table 11 indicate that the ratio between the maximum and minimum values for coliforms was about 1200:1. The equivalent ratio for total suspended solids was 171:1, and for fixed suspended solids 252:1. Other parameters with higher concentration ratios than found for total suspended solids included aluminum, iron, and lead. The ratios were 745:1 for aluminum, 513:1 for iron, and 570:1 for lead.

8.1.2 COMPARISON WITH MUNICIPAL SEWAGE

It was indicated in the literature review that lead concentrations in stormwater could be as high as 200 times those found in sanitary sewage, while other metals could be at concentrations from 10 to 100 times as high.

Data for 1979 from the Annacis STP were extracted from Cain and Swain(27). The effluent data from this sewage plant were chosen since it received less stormwater than the Iona STP, and less metal plating wastes than the Lulu STP. The data indicate that the mean concentrations for all parameters except lead, were less in the stormwater runoff than in the primary treated sewage. The concentration of lead in stormwater was twice that found in the primary treated sewage.

When peak concentrations are examined however, a slightly different picture is noted. Ratios between maximum and minimum values have been included in Table 11 for stormwater, and Table 22 for effluent from the Annacis STP. The data indicate that peak concentrations are higher in stormwater, and these could create localized environmental impacts.

8.2 STORMWATER LOADINGS

Although loadings are reported in terms of kg/d, the case is rare where stormwater will flow throughout any entire 24-hour period. Usually, loads expressed as kg/d are extrapolated from shorter time intervals.

Loadings have been calculated for this report by two methods. One method simply averages the loadings obtained in Table 13, usually for 15-minute intervals and extrapolates these mean values to the loading per day by multiplying by a factor of 96. This method implies that the flows which occurred when samples were collected represented flows for the entire day when samples were collected. This is a gross oversimplification since stormwater does not usually flow throughout an entire 24-hour period.

The second method uses the flow-weighted mean concentrations and calculates the loading with the average daily wet-weather flow. This method is likely to produce a better estimate of the true loading reaching the receiving stream than the first method. As well, the average daily wet-weather flow permits the total flow of stormwater to be equally spaced throughout the 365 days of the year, permitting easy comparison with other loadings such as from sewage treatment plants which discharge continuously.

A comparison of loadings calculated by each of these methods is included in Table 24. The data indicate that the method using flow-weighted mean concentrations and average flows produces considerably lower loadings.

8.2.1 SOURCES OF LOADINGS

Contaminants in stormwater can originate as material which has been deposited as dry dustfall and is subsequently picked up by the stormwater, or can be introduced directly with the rainfall.

In an attempt to determine the major sources of some contaminants found in the stormwater runoff, concentrations in precipitation and in dustfall were examined. Means were compared by expressing the loadings in terms of $t/km^2/mo$ and then calculating the ratio of the precipitation to dustfall loadings. A ratio of <1:1 indicated that dry deposition was the major source of the contaminant loading, while a ratio of >1:1 indicated that precipitation was the major source. The data are included in Table 26.

Only five parameters were measured in both the precipitation and dustfall samples. Chloride and sodium resulted mostly from dry deposition sources. The metals resulted mostly from precipitation, with copper and lead having ratios of >2:1.

The loadings of copper, lead, and zinc in the stormwater attributable to precipitation and dry deposition were determined using the ratios calculated in Table 26, the average runoff coefficient of 0.40 calculated in Table 9, and the loading balance from wet weather once dry weather loadings were taken into account (Table 24). Results are given in Table 27. Precipitation and dry deposition sources accounted for nearly 90% of the copper loading in stormwater, about 75% of the lead loading, and all of the zinc loading. The entire nitrogen loading could be accounted for in precipitation, but only about 30% of the phosphorus. These latter two parameters were not measured in the dustfall.

The unaccounted for lead and phosphorus could come from two separate sources. Vehicular emissions are likely responsible for lead. Some of these emissions would be measured in the dustfall, but unlikely all since the amount of lead recorded in the dustfall would not include all the lead emitted from vehicles at elevations lower than the dustfall cannisters. Cannisters were about two metres from the ground surface. Since most auto emissions are less than one metre from the ground, and are directed either horizontally or downward, it is likely that only a certain percentage of actual lead emitted would be detected in the dustfall samples.

Phosphorus likely originated from many commercial fertilizers applied in a typical residential area. It is estimated that approximately 6.5 hectares of the catchment area is pervious. If 50% of this area is fertilized at an application rate of 34 kg P/ha(43), approximately 110 kg of phosphorus will be applied yearly in the catchment area.

8.2.2 FIRST HOUR LOADINGS

Samples were collected for twelve storms during the first hour of recorded runoff. These data are included in Table 23. The data have been extrapolated for all residential areas within the Fraser River Estuary Study area as well as all types of drainage areas in the Study area using factors from Ferguson and Hall. Also included in Table 23 are data for 1979 from the three main sewage treatment plants (Annacis, Lulu, and Iona).

Ferguson and Hall had indicated that the runoff from the first hour of a moderate to heavy storm would contribute more pollutants on average than the city's sanitary sewerage system during the same time period. The term "moderate to heavy" was not defined.

The data in Table 23 indicate that the suspended solids, COD, aluminum, lead, copper, and zinc were higher in the stormwater discharged in the first hour than the equivalent average loads from the municipal primary sewage treatment plants. Total nitrogen and total phosphorus loads in the stormwater however, were less than those discharged from the three sewage treatment plants. Thus, Ferguson and Hall's hypothesis would appear to be correct for some of the major contaminants other than nutrients.

When a comparison is made between the first hour load from stormwater and the peak hourly load from the sewage treatment plants, the loads of lead, copper, and zinc in stormwater were still higher.

8.2.3 FIRST FLUSH

The literature cited in Chapter 2 indicated that a first flush in residential areas could be expected on about 80% of samplings for metals in stormwater. This means that one would expect to find higher metal loadings eighty percent of the time during the first portion of a storm.

To determine whether a first flush of contaminants existed at the site for different parameters, the method developed by Griffin and reported in Helsel _et_ _al_. for carrying out such a determination was used. Twelve individual storms where the first portion of the storm was sampled, were examined. The results are given in Table 25.

Griffin's method relates the incremental loading of a contaminant over a certain time interval for a storm to the total loading of the contaminant for the storm, and the incremental flow over the same time interval to the total flow for the storm. These relationships, designated as $^{I}/T$ in Table 25, are then expressed as a ratio of loading to flow for the same time interval. When the loading of contaminant is increasing at a greater rate than the flow for that time interval then the ratio is greater than 1, and a flush of contaminant occurs. The larger the ratio, the greater the flush of contaminant.

For most of the storms monitored in this study, sampling was not performed throughout the entire storm duration. For this reason the flow-weighted mean concentration was considered representative of the concentration throughout the entire storm and used to calculate the total storm load. If this resulted in actual loadings being greater than those calculated theoretically, no further computations were performed for that contaminant, as noted in the table.

Using this procedure the results in Table 25 show that a "first flush" of lead and nitrogen appeared in 75% of storms, of COD in 67% of storms, of aluminum in 50% of storms, of TOC and copper in 42% of storms, of suspended solids and zinc in 33% of storms and of total phosphorus in 16% of storms. Thus the predicted 80% of storms showing a "first flush" effect for metals was proved only for the case of lead.

The fact that a "first flush" is evident is important for future decisions on the possible treatment, and degree of treatment, of stormwater.

8.2.4 IMPACT ON RECEIVING WATERS

Stancil has indicated that sediments in the North Arm of the Fraser River contained higher levels of lead and zinc than in the Main Arm(29). Drinnan and Clark also indicated that lead was more frequently determined in the water of the North Arm compared to the Main Arm, while zinc levels in the North Arm were higner than in other river sections(30).

Figure 1 in Ferguson and Hall indicated that 44 storm sewers drained to the North Arm(3). Figure 6 from Cain and Swain indicated that there were 13 combined sewer overflows entering the North Arm(27). Stormwater has been shown to have higher levels of suspended solids, lead and zinc than domestic sewage, and is an integral portion of any combined sewer overflow. Thus stormwater is in all likelihood one of the major sources of the high lead and zinc values in the sediments and the water column of the North Arm.

8.3 TREATMENT OF STORMWATER

The City of Vancouver has initiated a program to treat some stormwater flows by constructing "first flush" separators. These devices divert flows from the bottom section of the stormwater pipe to a sanitary sewer. This is accomplished by constructing a small weir in the stormwater pipe, and diverting low flows through a 4 inch diameter pipe to the sanitary sewer. This system is attractive from a cost standpoint, and ensures that all small stormwater flows are treated. However, only a small proportion of contaminants in a large storm would receive treatment. It is unlikely that a large portion of lead in stormwater would be removed at the sewage treatments plants since volumes of stormwater would be appreciable compared to the volume diverted through a 4 inch diameter pipe.

Other methods by which stormwater can be treated have been discussed in Section 2.6. Since a "first flush" of lead and nitrogen was noted in about 75% of all storms (Section 8.2.3), the treatment of this "first flush" might be the most cost effective means of implementing some control over stormwater. This could be accomplished by constructing storage tanks throughout the collection system.

In order to design the storage tanks, the volume of the "first flush" to be treated has to be determined. The data in Table 25 indicate that "first flush" events lasted from one to three hours. Their volumes ranged from 20.6 m^3 to 254.7 m^3 for every 12.95 hectares of purely residential area, with a mean volume of 85 m^3 or 6.6 m^3/ha. Assuming a design between the worst case flow on record and the mean flow, a 75th percentile high volume would require a capacity of about 9.3 m^3/ha.

If storage was to be provided to the stormwater draining from the 17,640 ha of residential land determined by Ferguson and Hall to be draining to the Fraser River in the lower mainland, a total storage volume of about 164,000 m^3 would be required.

It should be noted that the design flow rate at the Annacis STP is 379 000 m^3/d, while it is 942 000 m^3/d at the Iona STP, and 61 200 m^3/d at the Lulu STP(27). Since the stormwater storage requirement is over 10% of the total daily design of the three sewage treatment plants, any implementation of storage schemes for stormwater would also require that the existing treatment capacities at each of the sewage treatment plants be examined.

9.0 CONCLUSIONS

9.1 RAINFALL

The rainfall quantity measured at a single site was representative of the rainfall which fell throughout the study area. During the course of the study, the rainfall was about 37% more than "normal" for the area.

The rainfall throughout the catchment area was generally acidic, with the pH being generally less than 5.6 (average pH approximately 4.86). Most of the acidity was in the form of weak acids. Throughout individual storms, no appreciable trend of either increasing or decreasing pH was apparent.

Precipitation contributed all the nitrogen loading and more of the copper, lead, and zinc loadings to the stormwater than did the dustfall. Precipitation contributed only about 30% of the phosphorus loading.

9.2 DUSTFALL QUALITY

Dustfall quality, measured at three sites, was consistent throughout the study area, with the exception of lead. Values for lead were significantly higher at a site close to large traffic volumes and associated lead emissions.

Chloride and sodium loadings resulted more from dustfall than from precipitation.

9.3 INFILTRATION AND RUNOFF

Mean soil moisture contents were reduced about 7% during the July through September period. This resulted in significantly reduced runoff coefficients in this period, the highest runoff coefficient during July and August being 0.35 compared to the mean for the study period of 0.40.

Infiltration measurements were significantly affected by the soil gradation of the undisturbed soil column under test. The results probably represent actual conditions throughout the study area. The data show that different soil types can either yield higher runoff or higher infiltration quantities, depending upon the soil gradation. The trends for mean soil moisture content were more meaningful in interpreting stormwater runoff, than were the data for infiltration and runoff.

9.4 STORMWATER RUNOFF QUALITY

Forty-five percent more runoff occurred than had been predicted by Ferguson and Hall for normal rainfall years. However, this occurred in a year when 37% more rainfall occurred than normal (Appendix 1).

Contaminant loadings are dependent upon the runoff coefficient. The mean runoff coefficient of 0.40 was slightly lower than used in early studies related to residential areas within the Greater Vancouver area. The effects of several factors including antecedent dry weather, maximum precipitation intensity during a storm, the storm duration, and the average storm precipitation intensity on the value of the runoff coefficient were examined using a multiple linear regression. The results indicated that storm duration was of most importance in determining the runoff coefficient.

Stormwater runoff from a residential catchment area was found to be non-acutely toxic to rainbow trout over a 96 hour test period. However, for Daphnia magna, the 96h LC50 was found to be 37%. This result indicates that the stormwater runoff can be acutely toxic to certain life forms. The toxicity was believed to be due to organics rather than metals in the runoff.

The concentrations of several constituents were proportional to flow. These included suspended solids, total and fecal coliform, aluminum, copper, lead, and zinc.

Analyses of dry-weather stormwater samples for commonly used pesticides, and polychlorinated biphenyls showed that these substances were not present in detectable quantities.

Coliform values were higher in stormwater than in effluents from the sewage treatment plants during summer months when the effluents are disinfected. However, during months when sewage effluents are not disinfected, coliform concentrations in stormwater are insignificant compared to the sewage treatment plant effluents.

Several constituents of the stormwater runoff were at concentrations less than those found in other studies. These included BOD_5, total nitrogen, total phosphorus, suspended solids, and total and fecal coliform. Only four metals were at higher concentrations than found in other studies, and these included copper, manganese, iron, and zinc. Concentrations during wet weather of total aluminum, copper, lead, and zinc were the same or higher than concentrations during dry weather. However, dissolved values of these metals were less during wet weather than dry weather. Therefore the higher values during wet flow conditions were related to metals associated with suspended matter.

Lower pH values during wet flow conditions as opposed to dry flow conditions can be attributed to the low pH of precipitation and the short retention time of the water on and in the soil. This short retention time affects the buffering of the water by the soil.

Stormwater has the potential to create localized increases in the concentrations of several parameters measured in the Fraser River. Constituents at higher concentration in stormwater than in the Fraser River included copper, lead, mercury, zinc, ammonia nitrogen, nitrate/nitrite nitrogen, organic nitrogen, and total phosphorus. However, only copper, lead, and zinc may be significant in terms of overall concentration increases in the Fraser.

The concentrations of cadmium, copper, and iron in stormwater sediments were approximately the same as in the sediments of the Fraser River Main Arm and its backwaters. Lead concentrations were higher in stormwater sediments, however manganese values were lower. Thus, sediment associated with stormwater from a residential catchment area will not increase metal concentrations already in the river.

The greatest variation between the minimum and maximum concentrations in stormwater (not sediments) occurred for total and fixed suspended solids, total and fecal coliform, aluminum, iron, copper, lead, organic carbon, ammonia and organic nitrogen.

Chloride and sodium in stormwater resulted mainly from dry deposition while copper, lead and zinc originated primarily from precipitation. Over twice as much copper and lead came from precipitation than from dry deposition. Also, all of the nitrogen and zinc loadings in the stormwater, and 90% of the copper loadings, came from either or both of these sources. However, significant sources of total phosphorus other than rainfall exist. These sources contributed 70% of the stormwater phosphorus loading, and are quite likely the fertilizers applied to residential areas.

During the first hours of a storm, loadings of suspended solids, COD, aluminum, lead, copper and zinc when extrapolated to all residential areas draining to the lower Fraser were higher than the mean loadings from Iona, Annacis, and Lulu sewage treatment plants. Any future requirement for the reduction of metals being discharged to the estuary area, such as to the North Arm of the Fraser River, should recognize stormwater as a major source of lead, copper and zinc which may require treatment.

A comparison of average daily loadings in stormwater from residential catchment areas to loadings from Iona, Lulu, and Annacis STP's has been made in Table 28. The comparison indicates that the average daily loading of lead from both sources is about equal, that the zinc loading from stormwater is about one-half, and the copper loading from stormwater about one-third the loading from the sewage treatment plants. Nitrogen and phosphorus from stormwater was only about one-fortieth the loading from the sewage treatment plants.

A "first flush" effect was evident in a considerable number of storms for lead, total nitrogen, COD, aluminum, TOC, copper, suspended solids and zinc. The existence of a "first flush" could enable its treatment as a means of controlling stormwater discharges. This could include the building of storage reservoirs which would permit treatment of the stormwater after a storm event had occurred. Such reservoirs should provide storage equivalent to at least 10 m^3/ha of residential land drained. Similar figures are not available for industrial or commercial type catchment areas, however the required volumes in these areas would be a function of the runoff coefficient and the existence of a "first flush".

10.0 RECOMMENDATIONS

The following recommendations are based upon the data presented in this report:

1. Rainfall and dustfall samples should be collected for any stormwater program undertaken in the future. For small catchment areas, only one sampling station should be necessary as long as it is not close to vehicular emissions.

2. Future stormwater monitoring programs should, as a minimum, utilize intensive sampling for at least the first 1 1/2 hours of any storm event. The exact length of the period of intensive sampling will be related to the particular catchment area, and may extend to as long as 3 hours.

3. Treatment of stormwater should be considered in any program to reduce the loadings of lead and zinc to the North Arm of the Fraser River. A detailed engineering feasibility study would be needed to consider all options to reduce lead and zinc loadings.

4. Similar studies to the one reported in this report should be undertaken in industrial and commercial catchment areas to determine possible treatment strategies.

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TABLE 1

1980 - 1981
PRECIPITATION RECORDS
RAINFALL GAUGE
ROSEMONT AND KERR

Day of Month	December, 1980 Hourly Rainfall* (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1	0.5						0.5	0.5	1			0.5		0.5	2	1	0.5			0.5	0.5	0.5	0.5	0.5	14	9.5
2			0.5	0.5	0.5	0.5	0.5	1	1		1	0.5	1	1	1	0.5	1	1	0.5	0.5					17	12.5
3													0.5	0.5	0.5		0.5	0.5	0.5		0.5	0.5			8	4
4								0.5		0.5	0.5		0.5	2	2.5								0.5		7	7
5								0.5				0.5		0.5	0.5	0.5	1	0.5	1	0.5	0.5		2.5	0.5	12	9
6	0.5																0.5								2	1
7																										
8						0.5	0.5	0.5					0.5												4	2
9					0.5							1.5	1	1	1	1.5	1	0.5			1	2	1.5	1.5	12	14
10	1	1	1.5	1.5							0.5						0.5	2.5	----------Missing----------						7	8.5
11	----------Missing----------																									
12	----------Missing----------																									
13	----------Missing----------																									
14	----------Missing----------								0.5								2.5	1	0.5						4	4.5
15																										
16																										
17																										
18																										
19																										
20									0.5	1	1	1.5	1.5	1	0.5	1.5	----------Missing----------								8	8.5
21	----------Missing----------																									
22	----------Missing----------																									
23	----------Missing----------																									
24	----------Missing----------																						0.5	0.5	2	1
25	0.5	1	2	1	0.5				0.5	1							0.5	3	3		6.5	2	2.5	2	14	26
26		2	2.5	5	6	3	4	2	1						2			0.5	4	2.5	1.5	1.5	0.5		15	38
27																				0.5	2.5	2.5	1.0	0.5	5	7
28																							0.5	0.5	2	1
29							1.5	0.5	0.5	0.5	0.5	0.5	1		1	1	1.5	0.5	0.5						12	9.5
30				0.5										0.5	2	0.5		0.5	0.5						6	4.5
31																										
																								TOTALS	151	167.5

* Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	January, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Hours of Rain	Daily Total (mm)
1																										
2																										
3																										
4																										
5																										
6																										
7																										
8																										
9																										
10									3.5					1.5											2	5
11																										
12																										
13																										
14																										
15																										
16																										
17																										
18															0.5	0.5	0.5								3	1.5
19					1	0.5	1	1		1	1.5	2													7	8
20																										
21																					1.5	1	2	1.5	4	6
22	0.5	0.5	0.5	------------RAIN GAUGE MALFUNCTION------------																					3	1.5
23	------------RAIN GAUGE MALFUNCTION------------																									
24	-----RAIN GAUGE MALFUNCTION-----																									
25																										
26	1																								1	1
27		0.5	1.5	1	0.5	0.5																			5	4
28																							1.5	2.5	2	4
29	3	0.5			0.5			0.5		0.5															5	5
30						1	1	1.5	0.5	1	1	1	0.5												8	7.5
31																										
																								TOTALS	40	43.5

* Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	February, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1																										
2																										
3																										
4																										
5																										
6																										
7																										
8																										
9																										
10																										
11															0.5	0.5	0.5	1	0.5	0.5	1.5	0.5	0.5		9	6
12								1	0.5		0.5	1.5	3	1.5	0.5	1	1	0.5	1	0.5	0.5		0.5		14	13.5
13		0.5	0.5	0.5	0.5	0.5		1	2	2	1.5	0.5	0.5	1		0.5							1.5	0.5	15	13.5
14	0.5	2	3.5	2.5	0.5																			0.5	6	9.5
15	3.5	1.5	0.5			0.5	1	0.5			0.5	1.5	3.5	3.5	3.5	4.5	1.5								13	25
16	0.5	1.5	1	1	0.5	1.5	2.5	0.5					0.5	1.5	1.5	1	0.5	0.5							14	14.5
17		1															1	1.5	2	2.5	8	2	1.5	1	9	20.5
18	1.5	0.5																		0.5	2	1.5	1	2.5	7	9.5
19	0.5		0.5	4.5	0.5																				4	6
20													0.5	1	1	1.5	1	0.5	0.5	1	0.5	1.5	1.5	1.5	12	12
21	1.5	1	1	0.5												0.5									5	4.5
22																										
23																										
24															0.5	1	1	1	1	1	1	0.5	0.5	0.5	10	8
25		1	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5											11	6
26						0.5	0.5	1	1	0.5															5	3.5
27																										
28																										
																								TOTALS	134	152

*Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	March, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1																										
2																						0.5	1	1	3	2.5
3	1	1	1	0.5	1.5	2.5	1.5	2.5	3.5	2.5	4	3.5	1.5												13	26.5
4							RAIN GAUGE MALFUNCTION																			
5	RAIN GAUGE MALFUNCTION																									
6	RAIN GAUGE MALFUNCTION																									
7	RAIN GAUGE MALFUNCTION																									
8																										
9																										
10																										
11																										
12																										
13																										
14																										
15									0.5	0.5	0.5	1	0.5	1.5	2	0.5	0.5	1.5	2.5	1.5	1	0.5			14	14.5
16																										
17																										
18																										
19																										
20																										
21																										
22	0.5	2.5	0.5																						3	3.5
23				0.5	1.5	0.5	1	0.5																	5	4
24																							1	3.5	2	4.5
25	2.5	2.5	3	2.5																					4	10.5
26																										
27																										
28													1.5	1	1.5	2.5	2	1.5	2	2	3	1	1.5	1.5	12	21
29	1.5	2	2	2	3	2.5	1						0.5	1.5	1.5	1.5	1	2	1	1.5	0.5				16	25
30								0.5	1	2	1.5	3.5	3.5	2	1	1	0.5	1	0.5	0.5	0.5	1.5	1	1.5	17	23
31	1.5	0.5	1	2	1	0.5	0.5	0.5																	8	7.5
																								TOTALS	97	142.5

*Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Hours of Rain	Daily Total (mm)
	April, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																									
1											1														1	1
2									1.5	0.5		0.5						0.5	0.5	0.5	0.5	0.5			8	5
3															----------VANDALISM----------											
4	------VANDALISM-----rainfall occurred------------------------------														1	1	0.5				0.5	0.5	1.5	3	7	8
5	2.5	2.5	2.5	0.5	2	0.5																			6	10.5
6																										
7															0.5										1	0.5
8	0.5	1	1.5	1.5	1	2	1	1	1	1.5	2	3	0.5												13	17.5
9																										
10				0.5																	0.5	0.5		0.5	4	2
11	0.5	0.5	0.5																						3	1.5
12			2	1	1	1.5	1.5	2.5	6	2.5	1.5	1													10	20.5
13																										
14																										
15																										
16																										
17																										
18																										
19																										
20																1.5	1	1	1	1.5				0.5	6	6.5
21	0.5	0.5	1	2	1.5	1	0.5	0.5	0.5			1		0.5	0.5	1.5	1	0.5	1	1.5	3	2.5	3	2.5	21	26.5
22	3.5	2.5	2.5	3	2	1	1.5	1			0.5	1	1	1	0.5		0.5		0.5	0.5					16	22.5
23													0.5	1.5											2	2
24																										
25																										
26																										
27							0.5	1	1	2	3	2	1.5	0.5	0.5	1	2.5	0.5	1.5	0.5	0.5		0.5		16	19
28							2.0	1.5	1	0.5															4	5
29	0.5	0.5					0.5			0.5	0.5														5	2.5
30																1.5									1	1.5
																								TOTALS	124	152

* Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Hours of Rain	Daily Total (mm)
	May, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																									
1																			0.5						1	0.5
2	1	1	0.5	0.5	0.5																			0.5	6	4
3									1	1	0.5	1	1.5	3.5	7	5	1.5	0.5	1		0.5	0.5	0.5		14	26
4		0.5	1	1.5	1.5	0.5					0.5														6	5.5
5																										
6					0.5	0.5	0.5	0.5	0.5											-------	-------	VANDALISM	-------	-------	5	2.5
7	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	VANDALISM	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------		
8	-------	-------	-------	-------	-------	VANDALISM	-------	-------	-------	-------	-------											0.5	0.5	0.5	3	1.5
9	0.5	0.5	0.5	0.5																					4	2
10																					2	0.5			2	2.5
11																										
12																										
13												0.5	0.5												2	1
14							1.5	1	0.5	3	0.5			0.5	1										7	8
15						1	2	0.5																	3	3.5
16																										
17																			1	0.5					2	1.5
18																	0.5	1	0.5	0.5	1.5	4.5	0.5		7	9
19																	0.5								1	0.5
20																										
21					0.5	0.5				0.5	0.5														4	2
22																										
23																				0.5		0.5		0.5	3	1.5
24					1			1.5						0.5						2	4.5	8	1.5	0.5	8	19.5
25	1.5	1	0.5																						3	3
26																										
27																										
28																										
29																0.5	1		0.5	2			0.5	1	6	5.5
30																					0.5	1.5			2	2
31																										
																								TOTALS	89	101.5

* *Where no data are indicated, no measurable precipitation occurred.*

TABLE 1 (Continued)

Day of Month	June, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1																										
2																										
3																					0.5	1.5	1.5	0.5	4	4
4					1		0.5	0.5	1	1															5	4
5							1	1			DATA UNRELIABLE	----	----	----	----	----	----	----	----	----	----	----	----	----		
6	DATA UNRELIABLE	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
7	DATA UNRELIABLE	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
8	DATA UNRELIABLE	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
9	DATA UNRELIABLE	----	----	----	----	----	----	----	----	----	----	----	1	2.5	2	1.5	1.5	1.5	0.5		0.5	1.5	1.5		10	14
10			0.5																	9.5	1.5	0.5			4	12
11					0.5		1.5	4	1.5						0.5	2									6	10
12																										
13												5	3												2	8
14	1.5	1	3.5	3	1	0.5	1.75	1	1	1	1	0.5													12	16.75
15																										
16																1	1.5	2	0.5	0.5					5	5.5
17																										
18																					0.5		0.5		2	1
19					0.5	2.5	1.5	2	4	1	1.5	1	0.5	1	2	0.5	3	2.5	2						15	25.5
20																							0.5	1	2	1.5
21																										
22										1	1.5	0.5	0.5								1		0.5	1	7	6
23	0.5							0.5				0.5	2												4	3.5
24	1.5	2.5	2.5	1																					4	7.5
25																										
26																										
27																										
28																										
29																							2.5	1	2	3.5
30	1	0.5		1	1.5			1.5	1	1															7	7.5
																								TOTALS	91	104.75

* Where no data are indicated, no measurable precipitaion occurred

TABLE 1 (Continued)

Day of Month	July, 1981 Hourly Rainfall (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1																										
2																										
3																										
4																										
5																										
6							0.5																		1	0.5
7																			4	23	4	2			4	33
8	0.5	3	1.5	1	0.5														1						6	7.5
9																										
10																										
11	0.5											0.5	0.5	0.5											4	2
12																										
13																										
14													0.5												1	0.5
15																										
16																										
17																										
18																										
19								0.5										0.5	0.5						1	1.5
20											0.5	0.5													1	1
21																										
22																										
23																										
24																										
25																										
26																										
27																										
28																	1.5	1.5	1.5	1.5					4	6
29																										
30																										
31																										
																								TOTALS	22	52

* Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	August, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1																										
2																										
3																										
4																										
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										
13																										
14																										
15																										
16																										
17																										
18																										
19																										
20				6.5	0.5	2	7.5	1	0.5																6	18
21																										
22																										
23																										
24																										
25					1	2.5	2.5	1.5	5.5	2															6	15
26																										
27																										
28																				0.5			0.5	0.5	3	1.5
29																										
30																										
31										0.5	1	0.5	0.5	1.5	2	5	5	2.5	1	1					11	20.5
																								TOTALS	26	55

* Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	September, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Hours of Rain	Daily Total (mm)
1	0.5	2																							2	2.5
2																										
3												DATA UNRELIABLE														
4												DATA UNRELIABLE														
5												DATA UNRELIABLE														
6			DATA UNRELIABLE											---	---	---	---	---	---	---	---	---	---	---		
7																										
8																										
9											1.5	0.5	2.5	0.5											4	5
10																										
11																										
12																										
13																										
14																										
15																										
16																										
17																										
18																										
19																										
20															0.5		0.5	1	4.5	8.5					5	15
21		0.5	2.5	1	0.5												1	2.5	0.5	0.5				0.5	9	9.5
22		1	1.5	2	1.5																				4	6
23																			RAIN GAUGE VANDALIZED							
24												RAIN GAUGE VANDALIZED														
25												RAIN GAUGE VANDALIZED														
26					RAIN GAUGE VANDALIZED																2	2			2	4
27	0.5	2	1				0.5	0.5	0.5			1	0.5	2.5	3	0.5		0.5			0.5	1			14	14.5
28	0.5	1	1.5	1	1	3.5	1	0.5					0.5												9	10.5
29																										
30		0.5	1	2	2	2	1.5	0.5		0.5			0.5												9	10.5
																								TOTALS	61	80.5

* Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	October, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1					2	1		2	2.5	5	3	3.5	4	3.5	1.5	2.5	2		2	0.5					14	35
2																			0.5	0.5					2	1
3																										
4																										
5											1.5	0.5	0.5	2	0.5	3	0.5	0.5	0.5	0.5	2.5	1	1	0.5	14	15
6			1		2.5											0.5	0.5	0.5	1.5	1	4	0.5	2.5	1	11	15.5
7							1	0.5	0.5	0.5									0.5	1	0.5	1.5	0.5		9	6.5
8				0.5	0.5	0.5								2	2	1.5	4	4							8	15
9		0.5				0.5	1.5	1.5	0.5	0.5	1.5														7	6.5
10																										
11																										
12																										
13																										
14																										
15																										
16																										
17																										
18																										
19																										
20																										
21																										
22																										
23																										
24																										
25																										
26															0.5	1	1.5	1					0.5	1	6	5.5
27				0.5	2.5	1	3	1.5	1	1			0.5											1	9	12
28	2.5	1.5	1		0.5	0.5		0.5				1.5		1.5							0.5				9	10
29																										
30										1.5	2	1.5	1.5	0.5	0.5	0.5	1.5	1	1.5	3	5.5				12	20.5
31	2.5	6	5.5	1.5	1.5	1	1	1	4	3.5	2.5	8	5.5	2.5	4	5.5	4	2.5	1.5	0.5	0.5		0.5	0.5	23	65.5
																								TOTALS	124	207.5

* Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	November, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1				0.5	1.5																				2	2
2																										
3																										
4																										
5																										
6																										
7																										
8																										
9																										
10																		0.5						0.5	2	1
11			1	2	3	4.5	0.5		0.5	0.5	0.5	1	0.5				0.5	0.5	0.5	0.5	0.5	1	0.5	1.5	18	19.5
12	4	2	3.5	1											0.5										5	11
13							0.5	0.5	2.5														0.5	1.5	5	5.5
14	2	0.5	0.5						3.5	1	0.5		1	0.5											8	9.5
15													1	0.5	2	4	2						0.5		6	10
16															0.5										1	0.5
17									0.5	0.5	2	0.5	0.5	0.5	0.5	0.5	1.5	2.5	2	0.5	1.5	2	2	1	16	18.5
18					2	2.5					0.5														3	5
19														0.5	1.5	4	4.5	1.5			0.5				6	12.5
20																							1	2.5	2	3.5
21	3.5	1	0.5		0.5	0.5	1	2	2	0.5						1	0.5	0.5	1.5					1.5	14	16.5
22	0.5						1.5		1	0.5		0.5							1	0.5	1	0.5	1	3	11	11
23	2	0.5													2.5	1		0.5							5	6.5
24			1	7	1	0.5																			4	9.5
25					1	2.5	2.5	1.5	2	0.5	1	1	1	0.5		0.5			0.5						12	14.5
26																										
27																										
28																										
29					1	1	1	0.5												1					4	4.5
30									1.5	0.5	0.5	1	2	2.5	2.5	2.5	3	3.5	2.5	3.5	5	4	5	0.5	16	40
																								TOTALS	140	197

* Where no data are indicated, no measurable precipitation occurred.

TABLE 1 (Continued)

Day of Month	December, 1981 Hourly Rainfall* (Millimetres) for Hour Ending at																								Hours of Rain	Daily Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1	1															1.5	3.5	1.5	1.5	2.5	3.5	6.5	3.5	2	10	27
2	1	0.5																							2	1.5
3										4.5	2.5	0.5		0.5	1										5	9
4															1		1	1.5	1.5	1.5	1	0.5	0.5	0.5	9	9
5																										
6						0.5		0.5															2	2	4	5
7	1	0.5				0.5	1	1	0.5																6	4.5
8																					0.5	1.5			2	2
9					0.5	0.5	0.5	1.5	2.5	2	1	0.5	1	0.5		2	1.5		1.5	1	1	0.5	0.5	0.5	18	19
10		3	1		0.5		0.5				0.5	0.5	1		0.5										8	7.5
11																										
12																										
13																1	1	1.5	1.5	1.5	0.5	0.5			7	7.5
14																										
15			1.5	2.5	1	0.5	0.5	0.5								0.5									7	7
16																										
17																										
18						1.5	1		1	3	2.5	2.5	1									1	1.5	2.5	10	17.5
19	2.5	1.5	0.5	1.0	1					0.5	0.5	0.5	0.5	0.5											10	9
20																										
21																										
22													0.5											0.5	2	1
23				0.5	0.5			0.5	0.5		0.5	0.5	0.5	1	1	1	1	0.5			0.5		0.5	0.5	15	9.5
24		1	0.5	1.5	1.5	1.5	1	1	1	1	0.5	0.5				0.5	1.5								13	13
25															0.5							0.5	0.5	0.5	4	2
26	0.5	1	1	1.5	1	1.5	1.5	1	1	1	0.5														11	11.5
27																		1.5	2	1.5	0.5	0.5	0.5	0.5	7	7
28									0.5				------------------RAIN GAUGE DISMANTLED------------------												1	0.5
29																										
30																										
31																										
																								TOTALS	151	170

* Where no data are indicated, no measurable precipitation occurred.

TABLE 2

PRECIPITATION COLLECTORS
(cm)

	Dec. 1/80	Dec. 10/80	Dec. 12/80	Dec. 15/80	Dec. 23/80	Dec. 27/80	Dec. 31/80
Townhouse	0.55	6.32	1.32	2.06	0.69	8.22	2.08
Raingauge	0.55	5.76	1.23	1.92	0.55	7.95	5.59
Outfall	0.55	3.84	1.32	1.92	0.55	7.65	2.06
	Total Dec.	10% Rain gauge					
Townhouse	21.24						
Raingauge	23.55	2.36					
Outfall	17.89						
	Jan. 3/81	Jan. 10/81	Jan. 20/81	Jan. 21/81	Jan. 22/81	Jan. 26/81	Jan. 27/81
Townhouse	0.11	0.78	1.29	0.75	0.60	1.21	0.46
Raingauge	0.08	0.71	1.21	0.74	0.58	1.13	0.17
Outfall	0.08	0.77	1.29	0.75	0.61	1.10	0.17
	Jan. 30/81	Total Jan.	10% Rain gauge				
Townhouse	1.76	6.96					
Raingauge	1.64	6.26	0.63				
Outfall	1.86	6.63					
	Feb. 16/81	Feb. 17/81	Feb. 18/81	Feb. 19/81	Feb. 23/81	Feb. 26/81	Total Feb.
Townhouse	8.44	0.83	2.37	1.69	1.89	1.64	16.86
Raingauge	6.00	0.82	2.34	1.67	1.86	1.68	14.37
Outfall	8.14	0.78	2.32	1.73	1.76	1.64	16.37
	10% Rain gauge						
Townhouse							
Raingauge	1.44						
Outfall							
	Mar. 3/81	Mar. 17/81	Mar. 22/81	Mar. 23/81	Mar. 25/81	Total Mar.	10% Rain Gauge
Townhouse	3.21	1.77	0.36	0.32	1.63	7.29	
Raingauge	2.93	1.90	0.36	0.31	1.68	7.18	0.72
Outfall	2.88	1.74	0.34	0.27	1.69	6.92	
	Apr. 1/81	Apr. 3/81	Apr. 5/81	Apr. 9/81	Apr. 13/81	Apr. 23/81	Apr. 28/81
Townhouse	4.66	0.87	3.02	1.63	2.34	6.14	2.77
Raingauge	4.72	0.87	3.15	1.63	2.39	6.22	2.48
Outfall	4.45	0.82	3.07	1.39	2.15	6.14	2.69

TABLE 2 (Continued)

PRECIPITATION COLLECTORS
(cm)

	Apr. 29/81	Total Apr.	10% Rain gauge
Townhouse	0.12	21.55	
Raingauge	0.11	21.51	2.16
Outfall	0.10	20.86	

	May 4/81	May 5/81	May 6/81	May 11/81	May 14/81	May 18/81	May 26/81
Townhouse	3.82	0.05	0.20	0.43	0.71	1.03	2.52
Raingauge	3.27	0.09	0.22	0.37	0.32	0.99	2.33
Outfall	3.81	0.09	0.20	0.43	0.28	1.04	2.33

	Total May	10% Rain gauge
Townhouse	8.76	
Raingauge	7.59	0.76
Outfall	8.18	

	June 1/81	June 4/81	June 8/81	June 12/81	June 15/81	June 16/81	June 19/81
Townhouse	0.57	0.85	2.04	3.77	1.81	0.63	2.74
Raingauge	0.69	0.82	2.02	3.95	1.67	0.72	2.56
Outfall	0.77	0.79	1.92	3.92	1.84	0.71	2.80

	June 21/81	June 22/81	June 24/81	Total June	10% Rain gauge
Townhouse	0.46	0.41	1.03	14.31	
Raingauge	0.44	0.38	1.01	14.26	1.43
Outfall	0.48	0.36	1.01	14.60	

	July 1/81	July 7/81	July 8/81	July 10/81	July 21/81	July 29/81	Total July
Townhouse	1.10	4.28	0.08	0.02	0.60	0.00	6.08
Raingauge	1.09	4.22	0.14	0.04	0.36	0.43	6.28
Outfall	1.12	4.67	0.09	0.02	0.53	0.00	6.43

	10% Rain gauge
Townhouse	
Raingauge	0.63
Outfall	

	Aug. 21/81	Aug. 26/81	Aug. 30/81	Total Aug.	10% Rain gauge
Townhouse	1.70	1.40	0.05	3.15	
Raingauge	1.77	1.48	0.08	3.33	0.33
Outfall	2.07	1.50	0.09	3.66	

TABLE 2 (Continued)

PRECIPITATION COLLECTORS
(cm)

	Sept. 1/81	Sept. 17/81	Sept. 20/81	Sept/ 21/81	Sept. 22/81	Sept. 28/81	Sept. 30/81
Townhouse	2.47	0.37	0.26	1.81	1.05	2.99	1.06
Raingauge	2.49	0.32	0.27	1.92	1.07	2.72	1.07
Outfall	2.17	0.36	0.29	1.72	0.91	2.82	1.10
	Total Sept.	10% Rain gauge					
Townhouse	6.91						
Raingauge	6.78	0.68					
Outfall	6.55						
	Oct. 1/81	Oct. 4/81	Oct. 6/81	Oct. 7/81	Oct. 8/81	Oct. 13/81	Oct. 20/81
Townhouse	5.15	0.39	1.70	1.55	0.47	2.22	0.06
Raingauge	5.21	0.39	1.72	1.46	0.45	1.90	0.07
Outfall	4.39	0.38	1.70	1.40	0.444	1.64	0.05
	Oct. 27/81	Oct. 28/81	Oct. 30/81	Total Oct.	10% Rain gauge		
Townhouse	1.75	0.98	0.52	14.79			
Raingauge	1.80	0.98	0.55	14.53	1.45		
Outfall	1.64	0.86	0.54	13.04			
	Nov. 16/81	Nov. 18/81	Nov. 23/81	Nov. 26/81	Nov. 29/81	Total Nov.	10% Rain gauge
Townhouse	1.15	2.40	5.35	2.85	0.28	27.07	
Raingauge	1.27	2.14	4.93	3.16	0.27	27.15	2.72
Outfall	1.15	2.48	5.43	2.92	0.27	25.46	
	Dec. 2/81	Dec. 5/81	Dec. 7/81	Total Dec.	10% Rain gauge		
Townhouse	7.47	1.89	1.02	10.38			
Raingauge	7.76	2.08	1.04	10.88	1.09		
Outfall	7.40	1.77	1.04	10.21			

TABLE 3

MONTHLY PRECIPITATION RECORDS - VANCOUVER INTERNATIONAL AIRPORT

	Total Monthly Precipitation (mm)	Normal Monthly Precipitation (mm)	Percent Actual Over or Under (-) Normal
December 1980	232.3	165.4	40.4
January 1981	71.7	147.3	-51.3
February 1981	156.4	116.6	34.1
March 1981	126.1	93.7	34.6
April 1981	143.3	61.0	134.9
May 1981	82.0	47.5	72.6
June 1981	135.8	45.2	200.4
July 1981	39.0	29.7	31.3
August 1981	36.2	37.1	-2.4
September 1981	84.1	61.2	37.4
October 1981	200.2	122.2	63.8
November 1981	196.4	141.2	39.1
December 1981	188.0	165.4	13.7
TOTAL	1691.5	1233.5	37.1

TABLE 4a

RAINFALL QUALITY DATA
COMPARISON OF THREE SITES ON A SAMPLE BASIS

Date	October 31, 1980; 01:55 to 23:00			November 3, 1980; 09:00 to 13:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.38	4.33	4.56	4.69	4.31	4.39
Acidity - strong	49	60	<15	23	<15	<15
- total	89	109	113	48	191	150
Phosphate	0.031	0.031	0.049	<0.009	<0.009	<0.009
Nitrate	1.50	1.46	1.64	0.27	0.31	0.35
Ammonium	0.290	0.340	0.360	0.044	0.072	0.051
Nitrite	0.033	0.033	0.036	0.026	0.026	0.026
Cadmium*	<0.0005	<0.0005	0.0011	<0.0005	0.0007	0.0013
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.002	0.002	0.003	0.004	0.005	0.007
Lead*	0.013	0.007	0.005	0.010	0.007	0.008
Nickel*	<0.01	0.01	<0.01	<0.01	0.01	0.01
Zinc*	0.017	0.024	0.050	0.020	0.027	0.050

Date	November 3, 1980; 13:00 to 22:30			November 5, 1980; 06:00 to 08:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.80	4.82	4.82	4.51	4.39	6.84
Acidity - strong	16	19	-	39	57	<15
- total	37	45	-	79	151	128
Phosphate	<0.009	<0.009	<0.009	0.012	<0.009	0.031
Nitrate	0.53	0.40	0.44	1.33	1.37	3.81
Ammonium	0.042	0.033	0.026	0.380	0.350	0.049
Nitrite	0.016	0.016	0.016	0.036	0.036	0.023
Cadmium*	<0.0005	<0.0005	<0.0005	0.0005	0.0005	<0.0005
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	<0.001	0.003	0.002	0.003	0.004	0.005
Lead*	0.009	0.007	0.005	0.017	0.016	0.009
Nickel*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc*	0.006	0.013	0.008	0.190	0.031	0.090

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) [illegible]ity [illegible]eq/[illegible]

TABLE 4a (Continued)

Date	November 5, 1980; 08:00 to 09:15			November 6, 1980; 06:00 to 10:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	-	-	-	5.14	5.01	5.53
Acidity - strong	-	-	-	<15	<15	<15
- total	-	-	-	30	35	43
Phosphate	0.009	-	0.018	0.012	<0.009	0.015
Nitrate	0.49	0.53	1.15	0.40	0.40	0.35
Ammonium	0.110	0.077	0.650	0.027	0.029	0.062
Nitrite	0.023	<0.016	0.026	0.020	0.016	0.020
Cadmium*	0.0009	<0.0005	0.0013	<0.0005	<0.0005	0.0005
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.005	0.002	0.010	0.001	0.002	0.009
Lead*	0.008	0.008	0.040	0.004	0.004	0.004
Nickel*	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Zinc*	0.017	0.009	0.050	<0.005	0.006	0.050

Date	November 9, 1980; 08:00 to 12:30			November 9, 1980; 12:30 to 19:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.82	5.04	4.70	4.76	4.56	4.80
Acidity - strong	19	16	26	20	34	18
- total	55	55	50	58	72	50
Phosphate	<0.009	0.015	<0.009	<0.009	0.012	-
Nitrate	0.40	0.44	0.40	0.67	0.67	-
Ammonium	0.025	0.068	0.055	0.085	0.130	-
Nitrite	0.026	0.030	0.023	0.033	0.040	-
Cadmium*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005$^+$	<0.0005$^+$
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005$^+$	<0.005$^+$
Copper*	0.002	0.005	0.002	0.002	0.001$^+$	0.003$^+$
Lead*	0.002	0.002	0.003	0.005	0.008$^+$	0.010$^+$
Nickel*	<0.01	<0.01	<0.01	<0.01	<0.01$^+$	<0.01$^+$
Zinc*	0.010	0.036	0.076	0.026	0.006$^+$	0.005$^+$

$^+$ Metals determined from undigested sample.
* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	November 16, 1980; 15:00 to November 17, 1980; 05:00			November 17, 1980; 05:00 to 10:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.17	4.46	4.49	4.52	4.51	4.55
Acidity - strong	108	41	38	33	33	31
- total	244	90	92	79	83	68
Phosphate	0.043	0.025	0.028	0.046	0.012	0.015
Nitrate	1.60	1.51	1.60	1.37	1.37	1.55
Ammonium	0.035	0.240	0.340	0.300	0.300	0.310
Nitrite	0.036	0.043	0.046	0.036	0.030	0.030
Cadmium*	0.0018	0.0005	0.0009	<0.0005	<0.0005	0.0007
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.030	0.004	0.008	0.003	0.002	0.008
Lead*	0.029	0.018	0.030	0.009	0.012	0.011
Nickel*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc*	0.076	0.023	0.063	0.014	0.010	0.032

Date	November 18, 1980; 21:00 to November 19, 1980, 07:00			November 20, 1980; 0:00 to 12:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.60	4.41	4.57	4.18	4.22	4.25
Acidity - strong	45	65	40	85	68	60
- total	103	131	80	146	122	73
Phosphate	0.031	0.018	0.015	0.015	0.012	0.012
Nitrate	0.93	0.75	0.71	1.64	1.42	1.46
Ammonium	0.300	0.100	0.078	0.140	0.110	0.110
Nitrite	0.033	0.030	0.030	0.023	0.023	0.023
Cadmium*	0.0016	<0.0005	<0.0005	0.0025	<0.0005	<0.0003
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.030	0.004	0.002	0.010	0.003	0.003
Lead*	0.024	0.010	0.010	0.013	0.009	0.014
Nickel*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc*	0.084	0.012	0.011	0.026	0.007	0.008

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

Date	November 20, 1980; 12:00 to 14:30			November 26, 1980; 15:00 to 19:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	-	-	-	4.25	4.22	4.40
Acidity - strong	-	-	-	-	-	-
- total	-	-	-	-	-	-
Phosphate	-	-	-	0.022	0.037	0.018
Nitrate	-	-	-	0.62	0.62	0.62
Ammonium	-	-	-	0.170	0.140	0.130
Nitrite	-	-	-	0.026	0.056	0.049
Cadmium*	0.0050$^+$	<0.0005$^+$	<0.0005$^+$	<0.0005	<0.0005	<0.0005
Chromium*	<0.005$^+$	<0.005$^+$	<0.005$^+$	<0.005	<0.005	<0.005
Copper*	0.001$^+$	0.001$^+$	0.005$^+$	0.007	0.002	0.002
Lead*	0.021$^+$	0.006$^+$	0.007$^+$	0.040	0.040	0.040
Nickel*	<0.01	<0.01$^+$	<0.01$^+$	<0.01	<0.01	<0.01
Zinc*	0.026$^+$	<0.005$^+$	0.036$^+$	0.027	0.024	0.025

Date	November 26, 1980; 22:00 to November 27, 1980; 04:30			November 27, 1980; 04:30 to 10:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.97	6.28	5.59	5.05	5.09	5.26
Acidity - strong	-	-	-	-	-	-
- total	-	-	-	-	-	-
Phosphate	0.022	0.022	0.034	0.012	<0.009	0.028
Nitrate	0.62	0.49	0.62	0.40	0.40	0.67
Ammonium	0.077	0.040	0.056	0.091	0.042	0.056
Nitrite	0.053	0.039	0.030	0.016	<0.016	<0.016
Cadmium*	<0.0005	<0.0005	<0.0005	0.0007	<0.0005	<0.0005
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.003	0.002	0.003	0.004	<0.001	0.002
Lead*	0.006	0.003	0.005	0.006	0.005	0.005
Nickel*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc*	0.013	0.006	0.007	0.016	<0.005	0.015

$^+$ Determined from undigested sample
* Unfiltered - Metals determined using HNO_3/HCl Digestion

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	November 30, 1980; 09:20 to December 1, 1980; 08:30			December 1, 1980; 14:40 to December 2, 1980; 16:50		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.42	4.56	5.12	4.40	4.43	4.46
Acidity - strong	-	-	-	-	-	-
- total	-	-	-	-	-	-
Phosphate	0.028	0.028	0.009	0.015	0.018	0.022
Nitrate	1.59	1.28	1.24	1.11	0.98	0.11
Ammonium	0.310	0.310	0.150	0.160	0.130	0.074
Nitrite	0.072	0.069	0.053	0.040	0.040	0.040
Cadmium*	0.0006	0.0005	<0.0005	0.0007	<0.0005	<0.0005
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.014	0.010	0.008	0.008	0.006	0.004
Lead*	0.031	0.028	0.018	0.024	0.015	0.015
Nickel*	0.03	0.03	<0.01	0.01	<0.01	<0.01
Zinc*	0.060	0.015	0.020	0.020	0.010	0.010

Date	December 11, 1980; 06:45 to 09:15			December 14, 1980; 08:35 to December 15, 1980; 08:20		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.73	4.77	-	4.09	4.43	4.19
Acidity - strong	-	-	-	-	-	-
- total	-	-	-	-	-	-
Phosphate	0.031	0.049	-	0.034	0.022	0.018
Nitrate	0.80	0.71	-	1.20	1.06	1.33
Ammonium	0.170	0.120	-	0.380	0.230	0.220
Nitrite	0.026	0.026	-	0.030	0.026	0.023
Cadmium*	0.0007	0.0014	-	0.0023	0.0008	0.0027
Chromium*	<0.005	<0.005	-	<0.005	<0.005	<0.005
Copper*	0.004	0.007	-	0.018	0.006	0.007
Lead*	0.017	0.024	-	0.055	0.040	0.065
Nickel*	<0.01	<0.01	-	0.016	<0.01	<0.01
Zinc*	0.070	0.190	-	0.060	0.050	0.050

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	December 21, 1980; 09:00 to 15:00			December 21, 1980; 15:00 to 22:20		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.82	4.80	4.02	4.57	4.61	4.53
Acidity - strong	-	-	-	-	-	-
- total	-	-	-	-	-	-
Phosphate	<0.009	0.009	<0.009	0.015	0.009	0.009
Nitrate	0.31	0.40	0.31	0.80	0.71	0.71
Ammonium	0.073	0.090	0.066	0.180	0.074	0.070
Nitrite	0.023	0.023	0.020	0.040	0.033	0.033
Cadmium*	0.0017	0.0006	0.0006	0.0005	0.0005	<0.0005
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.004	0.005	0.002	0.009	0.002	0.002
Lead*	0.022	0.016	0.015	0.015	0.012	0.014
Nickel*	<0.01	0.04	<0.01	0.016	0.012	<0.01
Zinc*	0.050	0.022	0.021	0.030	0.009	0.005

Date	December 21, 1980; 22:20 to December 22, 1980; 08:20			December 22, 1980; 08:20 to 13:30		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.60	4.52	4.43	-	5.17	5.07
Acidity - strong	-	-	-	-	-	-
- total	-	-	-	-	-	-
Phosphate	0.012	0.009	0.009	-	0.018	0.015
Nitrate	1.11	1.20	1.02	-	0.62	0.44
Ammonium	0.150	0.150	0.079	-	0.130	0.043
Nitrite	0.020	0.020	0.023	-	0.053	0.043
Cadmium*	<0.0005	<0.0005	<0.0005	-	<0.0005	<0.0005
Chromium*	<0.005	<0.005	<0.005	-	<0.005	<0.005
Copper*	0.010	0.002	0.002	-	0.006	0.002
Lead*	0.016	0.010	0.006	-	0.011	0.007
Nickel*	0.01	0.01	<0.01	-	<0.01	<0.01
Zinc*	0.017	0.012	0.009	-	0.050	0.009

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

TABLE 4a (Continued)

Date	January 20, 1981; 21:00 to January 21, 1981; 08:00			January 21, 1981; 17:30 to January 22, 1981; 08:30		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.74	4.99	4.85	4.64	4.64	4.02
Acidity - strong	-	-	-	-	-	-
- total	-	-	-	-	-	-
Phosphate	0.021	0.061	0.043	0.015	0.034	0.037
Nitrate	0.58	0.53	1.02	0.71	0.67	5.23
Ammonium	0.150	0.190	0.230	0.280	0.280	0.270
Nitrite	0.046	0.062	0.056	0.033	0.033	0.030
Cadmium*	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.008	0.007	0.004	0.006	0.002	0.003
Lead*	0.014	0.045	0.021	0.012	0.010	0.008
Nickel*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc*	0.017	0.017	0.020	0.013	0.009	0.013

Date	January 27, 1981; 20:30 to January 28, 1981; 08:00			January 28, 1981; 08:00 to January 29, 1981; 08:30		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.97	4.84	4.80	4.40	4.35	4.39
Acidity - strong	-	-	-	-	-	-
- total	-	-	-	-	-	-
Phosphate	<0.009	<0.009	0.018	0.046	0.043	0.049
Nitrate	0.44	0.49	0.53	1.64	1.68	1.51
Ammonium	0.260	0.048	0.110	0.650	0.350	0.350
Nitrite	0.052	0.046	0.046	0.079	0.072	0.066
Cadmium*	0.0014	<0.0005	0.0008	0.0012	<0.0005	<0.0005
Chromium*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper*	0.016	0.002	0.021	0.015	<0.005	<0.005
Lead*	0.016	0.014	0.017	0.055	<0.001	0.001
Nickel*	<0.01	<0.01	<0.01	0.02	0.043	0.040
Zinc*	0.050	0.008	0.090	0.090	0.016	0.042

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

TABLE 4a (Continued)

Date	January 29, 1981; 08:30 to 15:30			February 11, 1981; 15:30 to February 12, 1981; 17:30		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.59	4.74	4.58	4.44	4.41	4.60
Acidity - strong	-	-	-	40	40	28
- total	-	-	-	95	95	80
Phosphate	0.031	0.058	0.077	0.015	0.018	0.015
Nitrate	1.37	1.28	1.28	0.71	0.93	0.53
Ammonium	0.530	0.420	0.420	0.072	0.079	0.049
Nitrite	0.092	0.086	0.086	0.082	0.088	0.076
Cadmium*	0.0008	<0.0005	<0.0005	<0.0005	<0.0005	0.0007
Chromium*	<0.005	<0.005	<0.005	-	-	-
Copper*	0.008	<0.001	<0.001	0.007	0.004	0.005
Lead*	0.055	0.055	0.060	0.030	0.028	0.017
Nickel*	<0.01	<0.01	<0.01	-	-	-
Zinc*	0.045	0.035	0.026	0.030	0.020	0.070

Date	February 12, 1981; 17:30 to February 13, 1981; 06:00			February 17, 1981; 15:00 to 21:30		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.31	4.35	4.36	4.64	4.70	4.74
Acidity - strong	55	45	48	38	25	23
- total	138	113	88	60	53	58
Phosphate	0.166	0.018	0.015	0.009	<0.009	0.015
Nitrate	1.46	1.02	1.20	0.75	0.75	0.71
Ammonium	0.460	0.086	0.086	0.150	0.087	0.094
Nitrite	0.063	0.059	0.069	0.020	0.017	0.020
Cadmium*	0.0012	<0.0005	0.0031	<0.0005	<0.0005	<0.0005
Copper*	0.025	0.002	0.003	0.004	0.002	0.002
Lead*	0.028	0.021	0.025	0.008	0.006	0.005
Zinc*	0.150	0.011	0.070	0.020	0.011	0.024

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

TABLE 4a (Continued)

Date	February 17, 1981; 21:30 to February 18, 1981; 09:00			February 18, 1981; 18:45 to 22:30		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.84	4.93	5.19	4.92	4.95	5.02
Acidity - strong	18	<15	<15	<15	<15	<15
- total	48	45	43	48	45	43
Phosphate	0.009	0.012	0.009	0.012	0.012	0.018
Nitrate	0.75	0.71	0.71	0.44	0.40	0.40
Ammonium	0.140	0.068	0.073	0.130	0.120	0.088
Nitrite	0.026	0.026	0.023	0.040	0.040	0.036
Cadmium*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper*	0.006	0.001	0.001	0.004	<0.001	0.002
Lead*	0.006	0.003	0.003	0.015	0.006	0.010
Zinc*	0.030	0.008	0.026	0.025	0.008	0.070

Date	February 18, 1981; 22:30 to February 19, 1981; 07:15			February 24, 1981; 17:00 to February 25, 1981; 07:30		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.92	4.92	4.86	4.59	4.70	4.57
Acidity - strong	<15	<15	16	28	23	30
- total	40	38	41	70	55	68
Phosphate	0.009	<0.009	0.012	0.025	0.037	0.037
Nitrate	0.31	0.31	0.31	1.55	1.64	1.68
Ammonium	0.100	0.092	0.091	0.160	0.150	0.160
Nitrite	0.017	0.017	0.017	0.046	0.053	0.036
Cadmium*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper*	0.002	0.001	0.001	0.005	<0.001	0.002
Lead*	0.005	0.004	0.004	0.018	0.011	0.010
Zinc*	0.010	<0.005	0.028	0.018	<0.005	0.015

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	February 25, 1981; 07:30 to February 26, 1981; 08:00			March 2, 1981; 23:40 to March 3, 1981; 08:45		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.33	4.30	4.41	5.11	4.69	4.52
Acidity - strong	53	55	40	<15	25	33
- total	113	108	90	95	88	80
Phosphate	<0.009	0.021	0.028	<0.009	<0.009	<0.009
Nitrate	2.04	0.20	0.17	1.24	1.29	1.15
Ammonium	0.380	0.260	0.230	0.330	0.340	0.380
Nitrite	0.049	0.043	0.046	0.033	0.033	0.030
Cadmium*	0.0029	<0.0005	<0.0005	0.0007	<0.0005	<0.0005
Copper*	0.022	0.002	0.004	0.016	0.006	0.001
Lead*	0.040	0.027	0.017	0.110	0.080	0.011
Zinc*	0.070	0.012	<0.005	0.060	<0.005	0.024

Date	March 3, 1981; 08:45 to 10:30			March 3, 1981; 10:30 to 16:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.79	4.60	4.58	4.31	4.32	4.33
Acidity - strong	20	28	30	50	48	48
- total	80	75	75	118	116	111
Phosphate	<0.009	0.012	0.012	0.022	0.022	0.025
Nitrate	0.80	0.80	0.80	1.11	0.27	1.06
Ammonium	0.380	0.290	0.300	0.580	0.510	0.470
Nitrite	0.020	0.023	0.020	0.026	0.026	0.026
Cadmium*	0.0005	<0.0005	<0.0005	0.0005	<0.0005	<0.0005
Copper*	0.009	<0.001	<0.001	0.023	0.004	0.024
Lead*	0.085	0.038	0.008	0.040	0.031	0.014
Zinc*	<0.005	<0.005	<0.005	0.021	<0.005	0.015

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	March 24, 1981; 21:30 to 24:00			March 25, 1981; 00:01 to 09:45		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	5.99	5.78	5.24	5.06	5.08	4.79
Acidity - strong	<15	<15	<15	<15	<15	17
- total	54	45	80	39	43	47
Phosphate	0.012	0.031	0.058	0.012	0.018	0.015
Nitrate	1.02	1.11	1.51	0.71	0.66	0.75
Ammonium	0.480	0.440	0.630	0.250	0.210	0.240
Nitrite	0.033	0.039	0.036	0.020	0.023	0.023
Cadmium*	0.0029	0.0030	0.0024	0.0005	<0.0005	<0.0005
Copper*	0.100	0.080	0.012	0.015	0.016	0.008
Lead*	0.100	0.100	0.065	0.001	0.050	0.011
Zinc*	0.140	0.130	0.180	0.020	0.012	0.040

Date	March 29, 1981; 12:30 to 18:15			March 29, 1981; 18:15 to March 30, 1981; 07:20		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	5.40	4.96	4.72	5.05	5.70	5.34
Acidity - strong	<15	<15	22	<15	<15	<15
- total	41	49	56	53	35	38
Phosphate	0.015	0.031	0.031	0.022	0.046	0.043
Nitrate	1.20	1.20	1.02	1.02	0.93	0.98
Ammonium	0.160	0.170	0.160	0.230	0.098	0.110
Nitrite	0.053	0.036	0.030	0.046	0.069	0.060
Cadmium*	0.0007	0.0009	<0.0005	0.0008	<0.0005	<0.0005
Copper*	0.021	0.030	0.003	0.030	0.008	0.003
Lead*	0.080	0.080	0.017	0.050	0.032	0.015
Zinc*	0.060	0.05	0.013	0.060	0.010	0.013

* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	March 30, 1981; 07:20 to 15:00			March 30, 1981; 15:00 to 17:50		
Parameter	Townhouse	Raingauge	Outfall+	Townhouse	Raingauge	Outfall
pH	4.95	4.89	4.97	4.64	4.63	4.61
Acidity - strong	<15	15	<15	26	24	23
- total	39	36	39	58	50	54
Phosphate	0.012	0.012	0.022	0.015	0.015	0.015
Nitrate	0.49	0.44	0.40	0.58	0.62	0.71
Ammonium	0.110	0.077	0.085	0.210	0.099	0.120
Nitrite	0.023	0.017	0.020	0.023	0.020	0.017
Cadmium*	<0.0005	<0.0005	<0.0005	0.0008	<0.0005	<0.0005
Copper*	0.006	0.003	0.002	0.010	0.003	0.003
Lead*	0.018	0.015	0.016	0.026	0.021	0.009
Zinc*	0.011	0.007	0.020	0.030	0.006	0.020

Date	March 30, 1981; 17:50 to March 31, 1981; 07:45			April 2, 1981; 08:30 to 13:10		
Parameter	Townhouse	Raingauge	Outfall+	Townhouse+	Raingauge+	Outfall+
pH	5.77	5.51	5.50	5.28	5.04	4.54
Acidity - strong	<15	<15	<15	<15	<15	34
- total	32	52	53	59	55	110
Phosphate	0.028	0.025	0.012	0.028	0.028	0.074
Nitrate	0.71	0.71	0.62	1.68	1.91	1.73
Ammonium	0.100	0.091	0.088	0.390	0.320	0.370
Nitrite	0.049	0.030	0.036	0.036	0.026	0.023
Cadmium*	<0.0005	<0.0005	<0.0005	0.0013	0.0008	<0.0005
Copper*	0.005	0.002	0.002	0.017	0.020	0.007
Lead*	0.010	0.008	0.006	0.060	0.090	0.018
Zinc*	0.016	0.011	0.014	0.070	0.040	0.030

+ Some particulate materials present which may contribute to high dissolved ions.
* Unfiltered - Metals determined using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	April 8, 1981; 08:20 to 13:20			April 21, 1981; 07:45 to 17:45		
Parameter	Townhouse+	Raingauge+	Outfall+	Townhouse+	Raingauge	Outfall
pH	7.01	6.61	5.82	5.33	-	-
Acidity - strong	<15	<15	<15	<15	-	-
- total	24	27	90	84	-	-
Phosphate	0.025	0.018	0.015	0.031	-	-
Nitrate	0.49	0.35	0.09	2.21	-	-
Ammonium	0.180	0.130	0.034	0.47	-	-
Nitrite	0.066	0.030	0.020	0.059	-	-
Cadmium*	0.0029	0.0011	0.0040	0.0022	-	-
Copper*	0.040	0.020	0.010	0.021	-	-
Lead*	0.140	0.095	0.013	<0.100	-	-
Zinc*	0.170	0.100	0.028	0.140	-	-
Sodium	1.5	1.1	1.2	4.9	-	-
Sulphate	3.8	3.0	6.8	7.0	-	-
Potassium	0.4	0.2	0.9	4.0	-	-
Chloride	3.1	2.4	2.9	7.5	-	-
Calcium	2.81	1.67	1.12	2.12	-	-
Magnesium	0.29	0.23	0.31	0.18	-	-

Date	April 21, 1981; 07:45 to April 22, 1981; 10:00			April 22, 1981; 10:00 to April 23, 1981; 12:00		
Parameter	Townhouse++	Raingauge +	Outfall+	Townhouse	Raingauge+	Outfall
pH	4.86	4.99	4.90	6.37	6.85	6.20
Acidity - strong	<15	<15	<15	<15	<15	<15
- total	44	45	62	39	31	55
Phosphate	0.015	0.018	0.034	<0.009	0.018	<0.009
Nitrate	0.71	0.89	0.89	1.00	1.10	1.00
Ammonium	0.120	0.140	0.120	0.130	0.100	0.050
Nitrite	0.023	0.020	0.016	0.079	0.076	0.059
Cadmium*	<0.0005	0.0007	0.0006	<0.0005	<0.0005	<0.0005
Copper*	0.003	0.004	0.002	0.001	0.002	0.004
Lead*	0.028	0.045	0.008	0.010	0.010	0.005
Zinc*	0.009	0.020	0.020	0.005	0.013	0.020
Sodium	0.5	0.5	0.5	0.6	0.7	0.6
Sulphate	1.8	2.2	4.0	4.3	3.9	4.0
Potassium	0.1	0.1	0.2	0.2	0.1	0.2
Chloride	0.5	<0.5	0.5	0.8	0.8	0.8
Calcium	0.29	0.56	0.53	1.49	2.06	1.59
Magnesium	0.09	0.19	0.10	0.13	0.31	0.17

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.
+ Some particulate matter present in sample which may contribute to high dissolved ion results.
++Sampling commenced April 21, 1981 at 17:45 for this station only.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	April 28, 1981; 08:55 to April 29, 1981; 07:35			May 5, 1981; 15:25 to May 8, 1981; 11:15		
Parameter	Townhouse+	Raingauge	Outfall	Townhouse+	Raingauge+	Outfall+
pH	6.94	6.35	5.10	4.46	4.33	4.76
Acidity - strong	<15	<15	<15	37	44	24
- total	37	42	50	82	110	85
Phosphate	0.034	0.025	0.015	0.021	0.040	0.043
Nitrate	0.13	0.14	0.13	1.90	2.13	2.66
Ammonium	0.320	0.370	0.070	0.340	0.440	0.400
Nitrite	0.076	0.053	<0.016	0.033	0.033	0.046
Cadmium*	0.0016	0.004	0.0019	0.0024	0.0012	0.0055
Copper*	0.016	0.015	0.008	0.002	0.005	0.030
Lead*	0.050	0.050	0.010	0.060	0.040	0.090
Zinc*	0.070	0.110	0.100	0.060	0.040	0.100
Sodium	1.1	1.0	0.5	0.4	0.5	0.7
Sulphate	-	-	-	2.8	3.2	3.8
Potassium	0.3	0.4	0.6	0.1	0.1	0.2
Chloride	1.7	1.4	1.5	0.7	0.9	1.1
Calcium	3.03	1.21	-	0.90	0.73	1.60
Magnesium	0.25	0.11	-	0.07	0.05	0.10

Date	May 13, 1981; 07:45 to 17:30			May 14, 1981; 07:20 to 14:20		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall++
pH	-	-	-	4.32	4.36	4.37
Acidity - strong	-	-	-	54	53	53
- total	-	-	-	126	120	105
Phosphate	-	-	-	0.055	0.049	0.064
Nitrate	-	-	-	3.01	3.10	0.27
Ammonium	-	-	-	0.740	0.580	0.730
Nitrite	-	-	-	0.039	0.039	0.036
Cadmium*	0.0140	0.0210	0.0027	0.0026	0.0021	0.0014
Copper*	0.060	0.040	0.060	0.030	0.020	0.020
Lead*	0.300	0.500	0.300	0.110	0.130	0.040
Zinc*	0.180	0.300	0.230	0.050	0.050	0.140
Sodium	-	-	-	0.8	0.7	0.7
Sulphate	-	-	-	-	-	-
Potassium	-	-	-	0.2	0.1	0.4
Chloride	-	-	-	1.2	1.0	1.1
Calcium	-	-	-	0.92	0.94	0.09
Magnesium	-	-	-	0.12	0.09	0.09

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

+ Some particulate matter present in sample which may contribute to high dissolved ion results.

++Considerable amounts of particulate materials present in sample which may contribute to high dissolved ion results.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	May 14, 1981: 14:30 to May 15, 1981: 08:35			May 15, 1981: 15:50 to May 16, 1981: 08:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.43	4.45	4.39	-	-	4.52
Acidity - strong	38	40	47	-	-	36
- total	78	80	90	-	-	90
Phosphate	0.028	0.034	0.043	-	-	<0.009
Nitrate	1.51	1.59	1.77	-	-	1.37
Ammonium	0.150	0.140	0.340	-	-	0.140
Nitrite	0.023	0.016	0.020	-	-	0.026
Cadmium*	0.0010	0.0013	0.0013	-	-	0.0033
Copper*	0.003	0.003	0.014	-	-	0.014
Lead*	0.030	0.024	0.030	-	-	0.043
Zinc*	0.380	1.100	0.130	-	-	0.080
Sodium	1.4	1.6	1.8	-	-	0.4
Sulphate	2.4	-	2.7	-	-	2.2
Potassium	0.1	0.1	0.4	-	-	<0.1
Chloride	2.1	2.5	2.9	-	-	0.6
Calcium	0.47	-	-	-	-	0.55
Magnesium	0.10	-	-	-	-	0.03

Date	May 18, 1981: 18:40 to May 19, 1981: 12:00			May 24, 1981: 20:50 to May 25, 1981: 13:40		
Parameter	Townhouse	Raingauge	Outfall	Townhouse⁺	Raingauge⁺	Outfall
pH	4.72	4.35	4.88	6.03	6.26	5.36
Acidity - strong	22	17	16	<15	<15	<15
- total	62	60	65	42	37	42
Phosphate	<0.009	0.009	<0.009	<0.009	<0.009	<0.009
Nitrate	0.93	1.16	1.02	0.49	0.80	0.53
Ammonium	0.240	0.270	0.310	0.110	0.150	0.092
Nitrite	0.033	0.030	0.020	0.033	0.030	0.016
Cadmium*	<0.0005	0.0005	0.0007	0.0006	0.0008	<0.0005
Copper*	0.010	0.003	0.020	0.003	0.005	0.005
Lead*	0.028	0.022	0.020	0.014	0.017	0.012
Zinc*	0.023	0.280	0.050	0.020	0.040	0.030
Sodium	0.3	0.2	0.7	0.2	0.3	0.2
Sulphate	1.2	1.2	1.3	1.0	1.3	0.8
Potassium	0.1	0.1	0.2	0.1	0.1	0.1
Chloride	0.5	<0.5	1.1	<0.5	0.5	<0.5
Calcium	0.13	0.21	0.17	0.74	0.98	0.39
Magnesium	0.02	0.05	0.04	<0.02	0.03	0.02

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

⁺ Some particulate matter present in sample which may contribute to high dissolved ion results.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 1a (Continued)

Date	June 15, 1981: 15:37 to June 16, 1981: 08:05			June 17, 1981: 22:40 to June 18, 1980: 09:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.78	5.38		4.34	4.31	4.61
Acidity - strong	21	<15		47	18	27
- total	97	93		91	47	58
Phosphate	0.018	0.015		0.012	0.012	0.015
Nitrate	2.04	1.73		0.89	0.80	1.33
Ammonium	0.200	0.200		0.230	0.110	0.190
Nitrite	0.033	0.033		0.026	0.026	0.026
Cadmium*	0.0024	0.0028		0.0012	0.0007	0.0008
Copper*	0.020	0.018		0.010	0.005	0.005
Lead*	0.130	0.108		-	0.003	0.026
Zinc*	0.110	0.150		0.050	<0.005	0.060
Sodium	0.6	0.4		0.5	0.5	0.5
Sulphate	4.1	3.7		2.8	1.4	1.6
Potassium	0.1	0.1		0.1	0.1	0.1
Chloride	0.7	0.7		0.5	0.5	0.6
Calcium	1.86	1.70		0.44	0.29	0.21
Magnesium	0.06	0.13		<0.02	<0.02	<0.02

Date	June 18, 1981; 09:00 to 13:00			June 18, 1981; 13:20 to 16:40		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	5.01	4.84	4.85	4.56	4.54	4.45
Acidity - strong	<15	<15	17	30	30	37
- total	18	38	38	56	58	81
Phosphate	<0.009	<0.009	<0.009	<0.009	0.009	0.009
Nitrate	0.44	0.53	0.27	0.67	0.58	1.20
Ammonium	0.026	0.042	0.030	0.099	0.110	0.210
Nitrite	<0.016	<0.016	<0.016	0.023	0.020	0.020
Cadmium*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0058
Copper*	0.003	0.011	0.002	0.003	0.005	0.030
Lead*	0.016	0.022	0.013	0.028	0.033	0.100
Zinc*	0.070	0.021	0.030	0.010	0.050	0.060
Sodium	0.1	0.1	0.1	0.1	0.1	0.3
Sulphate	0.6	0.8	0.7	1.1	1.4	2.2
Potassium	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Chloride	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Calcium	0.10	0.09	0.05	0.08	0.09	0.14
Magnesium	0.43	<0.02	0.05	<0.02	<0.02	<0.02

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	June 18, 1981: 16:40 to June 19, 1981: 09:00			June 21, 1981: 11:50 to June 22, 1981: 09:10		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.49	4.46	4.29	5.62	5.94	4.71
Acidity - strong	34	36	54	<15	<15	24
- total	62	66	107	59	51	86
Phosphate	<0.009	<0.009	0.012	<0.009	0.037	<0.009
Nitrate	0.89	1.46	0.84	1.46	1.64	1.51
Ammonium	0.088	0.100	0.200	0.140	0.140	0.130
Nitrite	0.023	0.020	0.020	0.079	0.072	0.023
Cadmium*	<0.0005	0.0012	0.0059	0.0016	0.0013	-
Copper*	0.003	0.004	0.060	0.030	0.011	-
Lead*	0.031	0.033	0.100	0.300	-	-
Zinc*	0.014	0.390	0.180	0.480	0.040	0.150
Sodium	0.1	0.1	0.3	1.3	1.8	0.6
Sulphate	1.1	-	3.6	3.1	2.9	3.2
Potassium	<0.1	<0.1	0.2	0.1	0.1	0.1
Chloride	<0.5	<0.5	<0.5	0.9	0.9	0.9
Calcium	0.10	0.10	0.21	-	-	-
Magnesium	<0.02	<0.02	<0.02	-	-	-

Date	June 30, 1981: 07:45 to 11:00			July 6, 1981: 20:00 to 23:35		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	5.96	6.59	5.70	4.53	4.77	4.43
Acidity - strong	<15	<15	<15	35	19	38
- total	35	35	45	110	55	81
Phosphate	0.015	0.022	0.031	0.018	0.018	0.022
Nitrate	1.55	1.68	2.04	1.64	1.51	1.55
Ammonium	0.230	0.240	0.330	0.260	0.150	0.190
Nitrite	0.036	0.053	0.040	0.026	0.017	<0.016
Cadmium*	0.0018	0.0009	0.0011	0.0028	0.0007	0.0012
Copper*	0.004	0.004	0.012	0.010	0.013	0.080
Lead*	0.150	0.055	0.029	0.160	0.100	0.033
Zinc*	0.080	0.040	0.060	0.100	0.050	0.090
Sodium	0.5	1.2	0.6	1.0	0.9	0.9
Sulphate	-	4.6	-	9.9	3.2	2.4
Potassium	0.1	0.2	0.3	0.1	0.1	0.1
Chloride	0.8	1.7	1.7	1.3	1.2	1.3
Calcium	-	-	-	-	1.40	-
Magnesium	-	-	-	-	0.18	-

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	August 20, 1981; 06:15 to 09:35			August 25, 1981; 05:50 to 09:25		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	3.95	4.37	3.95	4.39	5.62	5.59
Acidity - strong	99	47	110	<15	<15	<15
- total	219	146	164	69	43	49
Phosphate	-	-	-	0.012	0.012	0.018
Nitrate	-	-	-	1.30	1.55	1.77
Ammonium	-	-	-	0.390	0.330	0.390
Nitrite	-	-	-	0.026	0.030	0.033
Cadmium*	0.0016	0.0020	0.0012	<0.0005	<0.0005	0.0009
Copper*	0.012	0.016	0.006	0.002	0.004	0.005
Lead*	0.045	0.200	0.038	0.008	0.018	0.025
Zinc*	0.030	0.130	0.060	<0.005	0.011	0.022
Sodium	-	-	-	0.5	0.5	0.7
Sulphate	-	-	-	2.3	1.7	2.0
Potassium	-	-	-	<0.1	<0.1	0.1
Chloride	-	-	-	0.7	0.6	0.7
Calcium	-	-	-	0.99	0.98	1.01
Magnesium	-	-	-	0.08	<0.02	<0.02

Date	August 25, 1981; 09:25 to 10:10			August 31, 1981; 09:20 to 17:25		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	5.19	-	5.31	4.65	4.58	-
Acidity - strong	<15	-	<15	22	29	-
- total	36	-	51	45	53	-
Phosphate	-	-	0.015	<0.009	0.012	-
Nitrate	-	-	0.89	0.80	1.42	-
Ammonium	-	-	0.190	0.240	0.280	-
Nitrite	-	-	0.030	0.016	0.017	-
Cadmium*	<0.0005	<0.0005	0.0012	<0.0005	<0.0005	0.0016
Copper*	<0.001	0.001	0.014	0.006	0.004	0.095
Lead*	0.009	0.007	0.070	0.013	0.013	0.142
Zinc*	0.005	0.007	0.021	0.020	0.028	0.170
Sodium	-	-	0.5	0.3	0.3	-
Sulphate	-	-	1.4	1.1	1.6	-
Potassium	-	-	0.1	0.1	0.1	-
Chloride	-	-	0.6	<0.5	<0.5	-
Calcium	-	-	0.38	<0.02	<0.02	-
Magnesium	-	-	<0.02	<0.02	<0.02	-

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

TABLE 4a (Continued)

Date	August 31, 1981; 17:25 to September 1, 1981; 08:00			August 31, 1981; 18:00 to September 1, 1981; 08:00		
Parameter	Townhouse++	Raingauge	Outfall+++	Townhouse	Raingauge	Outfall
pH	4.62	4.43	4.59	-	-	4.65
Acidity - strong	25	40	28	-	-	24
- total	56	79	59	-	-	64
Phosphate	<0.009	0.009	<0.009	-	-	<0.009
Nitrate	1.11	1.51	0.89	-	-	1.29
Ammonium	0.370	0.470	0.260	-	-	0.330
Nitrite	0.026	0.023	0.016	-	-	0.020
Cadmium*	<0.0005	<0.0005	<0.0005	-	-	<0.0005
Copper*	0.006	0.007	0.006	-	-	0.006
Lead*	0.017	0.021	0.040	-	-	0.031
Zinc*	0.016	0.021	0.025	-	-	0.015
Sodium	0.4	0.5	0.2	-	-	0.5
Sulphate	2.8	-	1.4	-	-	-
Potassium	0.1	0.1	0.1	-	-	0.1
Chloride	0.5	0.5	<0.5	-	-	0.6
Calcium	0.54	0.36	<0.02	-	-	0.61
Magnesium	<0.02	<0.02	<0.02	-	-	<0.02

Date	September 20, 1981; 14:15 to 19:40			September 20, 1981; 19:40 to September 21, 1981; 06:45		
Parameter	Townhouse+	Raingauge	Outfall+	Townhouse	Raingauge	Outfall
pH	5.35	5.65	5.21	5.94	6.17	5.95
Acidity - strong	<15	<15	<15	<15	<15	<15
- total	49	54	100	<15	24	48
Phosphate	0.022	0.015	0.012	<0.009	0.012	<0.009
Nitrate	0.98	1.11	1.20	0.49	0.80	0.75
Ammonium	0.240	0.260	0.370	0.120	0.160	0.040
Nitrite	0.023	0.023	0.020	0.026	0.033	<0.016
Cadmium*	<0.0005	<0.0005	0.0013	<0.0005	<0.0005	<0.0005
Copper*	0.004	0.004	0.015	0.002	0.003	0.004
Lead*	0.015	0.012	0.030	0.005	0.005	0.022
Zinc*	0.016	0.024	0.070	0.011	0.016	0.026
Sodium	0.5	0.4	0.5	1.4	1.5	1.4
Sulphate	1.2	1.3	0.9	1.0	1.4	1.4
Potassium	0.1	0.1	0.1	0.1	0.1	0.8
Chloride	0.5	0.6	1.0	2.4	2.5	2.5
Calcium	0.41	0.61	0.26	0.47	0.62	0.62
Magnesium	<0.02	<0.02	<0.02	0.07	0.07	0.09

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.
+ Particulate materials present in sample may contribute to high dissolved ion results.
++ Sample taken August 31, 1981; 09:20 to 11:15 for this station only.
+++Sample taken August 31, 1981; 11:15 to 18:00 for this station only.

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

TABLE 4a (Continued)

Date	September 21, 1981; 16:35 to September 22, 1981; 08:45			September 27, 1981; 16:00 to September 28, 1981; 05:50		
Parameter	Townhouse+	Raingauge+	Outfall+	Townhouse	Raingauge	Outfall
pH	7.06	6.96	6.6	5.02	5.15	5.43
Acidity - strong	<15	<15	<15	<15	<15	<15
- total	15	19	44	34	39	46
Phosphate	0.025	0.018	0.034	0.025	0.015	0.068
Nitrate	0.71	0.62	0.71	0.89	0.98	1.15
Ammonium	0.104	0.096	0.150	0.170	0.240	0.330
Nitrite	0.049	0.040	0.033	0.040	0.040	0.030
Cadmium*	<0.0005	<0.0005	0.0015	<0.0005	<0.0005	0.0007
Copper*	0.003	0.003	0.014	0.003	0.006	0.008
Lead*	0.010	0.020	0.012	0.011	0.014	0.011
Zinc*	0.020	0.013	0.030	0.020	0.030	0.030
Sodium	1.0	0.9	1.2	1.5	1.7	1.6
Sulphate	1.2	1.2	2.5	1.9	2.6	2.7
Potassium	0.1	0.1	0.8	0.2	0.2	0.3
Chloride	1.5	1.4	1.8	2.5	2.8	2.8
Calcium	1.52	1.29	1.35	0.36	0.60	0.43
Magnesium	0.06	0.05	0.09	0.04	0.06	0.04

Date	September 28, 1981; 05:50 to 09:45			September 29, 1981; 20:30 to September 30, 1981; 05:10		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	6.50	6.64	6.01	4.74	4.69	4.92
Acidity - strong	<15	<15	<15	17	21	<15
- total	22	24	18	48	52	48
Phosphate	-	-	-	0.012	0.012	<0.009
Nitrate	-	-	-	1.15	1.24	1.11
Ammonium	-	-	-	0.085	0.130	0.200
Nitrite	-	-	-	0.023	0.020	0.040
Cadmium*	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005
Copper*	0.003	0.004	<0.001	0.003	0.004	0.012
Lead*	0.003	0.008	0.004	0.014	0.010	0.010
Zinc*	0.006	0.008	0.006	0.008	0.011	0.052
Sodium	-	-	-	0.7	0.6	0.7
Sulphate	2.3	2.5	2.2	1.6	1.9	1.9
Potassium	-	-	-	0.1	0.1	0.1
Chloride	-	-	-	1.0	1.0	1.1
Calcium	-	-	-	0.30	0.26	0.30
Magnesium	-	-	-	0.03	0.04	0.03

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

+ Particulate materials present in sample may contribute to high dissolved ion concentrations.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	September 30, 1981; 05:10 to 13:05			October 1, 1981; 07:45 to 09:55		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	4.09	4.02	4.13	4.63	4.75	5.00
Acidity - strong	61	74	62	21	17	<15
- total	88	120	107	35	30	46
Phosphate	-	-	-	<0.009	<0.009	<0.009
Nitrate	-	-	-	0.89	0.71	0.67
Ammonium	-	-	-	0.150	0.130	0.200
Nitrite	-	-	-	<0.016	0.020	0.023
Cadmium*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0010
Copper*	0.003	0.003	0.008	0.004	0.003	0.008
Lead*	0.027	0.027	0.044	0.017	0.007	0.019
Zinc*	0.015	0.009	0.023	0.018	0.013	0.032
Sodium	-	-	-	0.6	0.5	0.6
Sulphate	-	-	-	2.0	2.3	3.6
Potassium	-	-	-	0.1	<0.1	0.1
Chloride	-	-	-	0.9	0.8	0.9
Calcium	-	-	-	0.09	0.15	0.37
Magnesium	-	-	-	0.02	0.03	0.03

Date	October 1, 1981; 09:55 to 13:10			October 5, 1981; 10:15 to 17:00		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	7.30	6.48	6.12	5.16	5.21	-
Acidity - strong	<15	<15	<15	<15	<15	-
- total	<15	21	38	58	43	-
Phosphate	<0.009	<0.009	<0.009	0.012	0.022	-
Nitrate	0.62	0.49	0.53	0.67	0.62	-
Ammonium	0.112	0.110	0.042	0.059	0.085	-
Nitrite	0.059	0.026	0.026	0.020	0.017	-
Cadmium*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	-
Copper*	0.002	0.002	0.004	0.002	0.002	-
Lead*	0.008	0.005	0.005	0.018	0.008	-
Zinc*	0.025	0.006	0.012	0.011	0.009	-
Sodium	0.7	0.6	0.6	0.4	0.2	-
Sulphate	2.8	2.4	2.8	1.8	1.3	-
Potassium	0.2	0.1	0.3	<0.1	<0.1	-
Chloride	1.0	1.0	1.0	0.7	<0.5	-
Calcium	1.63	0.95	1.10	0.30	0.17	-
Magnesium	0.07	<0.02	0.05	0.05	0.03	-

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 1a (Continued)

Date	October 5, 1981; 17:00 to 21:55			October 5, 1981; 21:55 to October 6, 1981; 06:40		
Parameter	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
pH	5.39	5.29	5.63	4.75	4.63	4.79
Acidity - strong	<15	<15	15	18	19	15
- total	32	30	37	43	44	50
Phosphate	0.025	0.049	0.117	<0.009	<0.009	<0.009
Nitrate	0.71	0.53	0.44	0.89	0.80	0.80
Ammonium	0.210	0.110	0.150	0.140	0.130	0.078
Nitrite	0.026	0.020	0.020	0.023	0.017	<0.016
Cadmium*	0.0100	<0.0005	0.0025	0.0006	<0.0005	0.0008
Copper*	0.020	0.001	0.045	0.003	<0.001	0.013
Lead*	0.027	0.008	0.027	0.016	0.005	0.017
Zinc*	0.080	<0.005	0.120	0.010	<0.005	0.028
Sodium	0.7	0.2	0.5	0.5	0.5	0.6
Sulphate	-	1.0	1.9	-	-	1.7
Potassium	0.3	<0.1	0.1	<0.1	<0.1	<0.1
Chloride	1.0	<0.5	0.8	0.9	0.9	1.1
Calcium	0.16	0.06	0.12	0.06	0.05	0.08
Magnesium	0.05	0.05	0.04	<0.02	0.02	0.02

Date	October 6, 1981; 06:40 to October 7, 1981; 06:30			October 7, 1981; 06:30 to 15:55		
Parameter	Townhouse+	Raingauge	Outfall+	Townhouse	Raingauge	Outfall
pH	5.39	5.16	5.18	4.39	5.08	5.42
Acidity - strong	<15	<15	<15	<15	<15	<15
- total	40	31	55	43	37	63
Phosphate	0.009	0.009	<0.009	0.012	0.015	0.101
Nitrate	0.62	0.62	0.58	0.71	0.84	0.71
Ammonium	0.078	0.130	0.056	0.140	0.180	0.180
Nitrite	0.023	0.020	<0.016	0.036	0.043	0.026
Cadmium*	<0.0005	0.0050	<0.0005	<0.0005	<0.0005	<0.0005
Copper*	0.003	0.006	0.003	0.001	0.001	0.004
Lead*	0.010	0.008	0.010	0.011	0.007	0.009
Zinc*	0.008	0.008	0.014	<0.005	0.005	0.016
Sodium	0.5	0.4	0.4	1.4	1.6	1.5
Sulphate	1.9	1.5	1.7	1.7	2.6	3.4
Potassium	0.1	<0.1	0.1	0.1	0.1	0.7
Chloride	0.7	0.6	0.6	2.5	2.9	3.0
Calcium	0.16	0.10	0.14	-	-	-
Magnesium	0.04	0.02	<0.02	-	-	-

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

+ Large amounts of particulate materials present in sample may contribute to high dissolved ion results.

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

TABLE 4a (Continued)

Date	October 3, 1981; 07:35 to 16:10			October 26, 1981; 14:10 to 20:00		
Parameter	Townhouse+	Raingauge+	Outfall	Townhouse	Raingauge	Outfall
pH	6.30	6.22	6.15	4.59	4.61	6.15
Acidity - strong	<15	<15	<15	29	28	<15
- total	37	43	72	67	59	180
Phosphate	0.022	0.025	0.098	0.009	0.009	<0.009
Nitrate	0.98	0.93	0.39	1.11	2.26	0.27
Ammonium	0.130	0.120	0.160	0.150	0.220	0.016
Nitrite	0.053	0.053	0.043	0.020	0.020	<0.016
Cadmium*	<0.0005	<0.0005	0.0025	<0.0005	<0.0005	<0.0005
Copper*	0.002	0.001	0.005	0.002	<0.001	0.035
Lead*	0.010	0.008	0.010	0.042	0.013	0.001
Zinc*	0.022	0.008	0.050	0.025	0.030	0.030
Sodium	1.1	1.0	1.0	0.2	0.2	0.3
Sulphate	2.6	3.1	4.6	2.8	2.7	5.9
Potassium	0.1	0.1	1.5	<0.1	<0.1	2.2
Chloride	1.8	1.9	2.0	<0.5	<0.5	1.3
Calcium	0.39	1.21	1.05	0.20	0.10	1.40
Magnesium	0.15	0.12	0.19	0.04	<0.02	0.37

Date	October 26, 1981; 20:00 to October 27, 1981; 06:50			October 27, 1981; 06:50 to 13:50		
Parameter	Townhouse+	Raingauge +	Outfall	Townhouse	Raingauge	Outfall
pH	6.34	5.32	6.35	4.51	4.69	6.08
Acidity - strong	<15	<15	<15	27	26	<15
- total	42	32	33	52	59	58
Phosphate	<0.009	0.046	0.012	0.009	0.012	<0.009
Nitrate	0.39	0.39	0.99	0.62	0.75	0.49
Ammonium	0.160	0.015	0.160	0.100	0.140	<0.007
Nitrite	0.099	0.030	0.105	0.020	0.020	<0.016
Cadmium*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper*	0.012	<0.001	0.006	0.001	0.001	0.013
Lead*	0.006	0.001	0.004	0.010	0.010	0.007
Zinc*	0.040	0.015	0.040	<0.007	0.005	0.013
Sodium	0.7	0.5	0.5	0.3	0.3	0.4
Sulphate	3.6	2.4	3.1	2.5	2.8	7.2
Potassium	0.3	0.4	0.2	<0.1	<0.1	1.9
Chloride	1.1	0.9	0.8	0.5	0.5	0.8
Calcium	0.18	0.27	1.92	0.06	0.14	-
Magnesium	0.09	0.09	0.09	<0.02	0.04	-

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

+ Some particulate materials present in sample may contribute to high dissolved ion results.

(large organic particles - townhouse, October 26; 14:10 to 20:00 - raingauge, October 27; 06:50 to 13:55)

(sample appeared yellowish - outfall, October 26; 14:10 to 20:00)

(sample had fibers - raingauge , October 26; 20:00 to October 27; 06:50)

(sample organic plus fine particles - townhouse, October 27; 06:50 to 13:55)

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

TABLE 4a (Continued)

Date	October 27, 1981; 13:50 to October 28, 1981; 06:40			October 28, 1981; 06:40 to October 29, 1981; 07:00		
Parameter	Townhouse+	Raingauge+	Outfall	Townhouse	Raingauge	Outfall
pH	5.44	5.82	6.33	4.96	5.11	6.17
Acidity - strong	<15	<15	<15	<15	<15	<15
- total	38	32	154	59	49	61
Phosphate	0.015	0.046	0.012	0.025	0.018	<0.009
Nitrate	0.67	0.8	0.18	1.11	0.89	0.75
Ammonium	0.082	0.150	0.008	0.190	0.190	0.092
Nitrite	0.017	0.030	<0.016	0.036	0.033	0.023
Cadmium*	<0.0005	<0.0005	<0.0005	0.0006	<0.0005	0.0019
Copper*	<0.001	<0.001	0.009	0.013	0.005	0.011
Lead*	0.006	0.001	0.002	0.008	0.008	0.003
Zinc*	0.007	0.015	0.027	0.028	0.016	0.070
Sodium	0.5	0.5	0.6	1	0.5	0.7
Sulphate	2.5	2.4	4.1	2.4	-	3.2
Potassium	0.1	0.4	5.6	0.6	0.1	1.6
Chloride	0.8	0.9	2.4	1.5	0.7	1.0
Calcium	0.20	0.27	0.83	0.25	0.61	0.41
Magnesium	0.05	0.07	0.27	0.10	0.19	0.14

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

+ Some particulate materials present in sample which may contribute to high dissolved ion results.
(mostly larger organic materials)

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	November 10, 1981; 14:25 to November 11, 1981; 04:35			November 11, 1981; 04:35 to 06:45		
Parameter	Townhouse+	Raingauge	Outfall	Townhouse+	Raingauge**	Outfall+
pH	5.49	5.23	5.70	4.96	4.79	6.12
Acidity - strong	<15	<15	<15	<15	19	<15
- total	66	55	101	42	45	68
Phosphate	<0.009	<0.009	0.129	<0.009	<0.009	0.755
Nitrate	0.89	0.11	0.13	0.67	<0.09	<0.09
Ammonium	0.320	0.480	0.450	0.160	0.170	0.062
Nitrite	0.036	0.046	0.033	0.017	0.020	0.017
Cadmium*	<0.0005	0.0005	0.0014	<0.0005	<0.0005	0.0010
Copper*	0.008	0.015	0.013	0.001	<0.001	0.009
Lead*	0.024	0.022	0.015	0.009	0.006	0.030
Zinc*	0.012	0.009	0.090	0.005	<0.005	0.040
Sodium	0.5	0.4	1.1	0.4	0.3	0.3
Sulphate	2.7	2.3	3.3	1.1	1.4	2.5
Potassium	0.3	0.1	0.9	0.1	<0.1	0.2
Chloride	0.9	0.7	1.8	0.5	0.5	0.6
Calcium	0.68	0.58	0.60	0.09	0.05	0.53
Magnesium	0.09	0.08	0.15	0.02	<0.02	0.21

Date	November 11, 1981; 06:45 to 10:45			November 11, 1981; 10:45 to 22:05		
Parameter	Townhouse+	Raingauge +	Outfall+	Townhouse	Raingauge	Outfall
pH	6.58	6.52	6.41	5.30	5.68	6.12
Acidity - strong	<15	<15	<15	<15	<15	<15
- total	24	29	59	31	26	68
Phosphate	<0.009	0.012	0.012	<0.009	0.009	0.755
Nitrate	0.49	<0.09	0.35	0.35	<0.09	<0.09
Ammonium	0.030	0.110	<0.007	0.029	0.062	0.062
Nitrite	0.063	0.078	0.017	0.020	0.030	0.017
Cadmium*	<0.0005	<0.0005	0.0005	<0.0005	0.0018	0.0010
Copper*	0.008	<0.001	0.001	<0.001	<0.001	0.009
Lead*	0.007	0.002	0.014	0.003	0.006	0.030
Zinc*	<0.005	<0.005	0.035	<0.005	0.350	0.040
Sodium	0.7	0.7	0.8	0.3	0.3	0.3
Sulphate	1.4	1.1	3.1	1.0	1.1	2.5
Potassium	0.1	0.1	0.9	<0.1	0.1	0.2
Chloride	1.0	1.2	2.1	<0.5	0.6	0.6
Calcium	0.78	0.84	1.62	0.07	0.23	0.53
Magnesium	0.11	0.10	0.15	0.02	0.03	0.21

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.

+ Some particulate materials present which may contribute to high dissolved ions.

Note: Particulate materials present in all samples except where noted by (**). Quantities of particles varied, with samples noted as (+) having large organic flakes.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	November 12, 1981; 18:55 to November 13, 1981; 09:55			November 15, 1981; 12:35 to 17:10		
Parameter	Townhouse⁺	Raingauge	Outfall⁺	Townhouse⁺	Raingauge⁺	Outfall
pH	5.00	4.92	5.05	5.40	5.12	5.55
Acidity - strong	<15	<15	<15	<15	<15	<15
- total	59	49	49	39	34	42
Phosphate	0.025	0.009	0.031	<0.009	0.009	<0.009
Nitrate	1.02	1.11	1.29	0.35	0.49	0.49
Ammonium	0.140	0.210	0.140	<0.007	0.100	0.140
Nitrite	0.026	0.026	0.020	0.026	0.026	0.030
Cadmium*	<0.0005	<0.0005	<0.0005	0.0005	<0.0005	<0.0005
Copper*	0.007	0.006	0.007	0.005	0.002	0.006
Lead*	0.400	0.018	0.022	0.010	0.007	0.008
Zinc*	0.012	0.010	0.035	0.013	0.005	0.090
Sodium	0.7	0.7	0.9	0.5	0.4	0.6
Sulphate	2.3	1.9	2.6	1.9	1.3	1.9
Potassium	0.3	0.1	0.5	0.2	0.1	0.2
Chloride	1.3	1.3	1.6	0.7	0.5	0.7
Calcium	0.48	0.30	0.43	0.25	0.12	0.17
Magnesium	0.14	0.09	0.11	0.07	0.03	0.05

Date	November 15, 1981; 17:10 to 23:25			November 17, 1981; 06:30 to 14:35		
Parameter	Townhouse	Raingauge ⁺	Outfall	Townhouse⁺	Raingauge⁺	Outfall
pH	5.66	6.03	5.69	5.06	5.22	5.91
Acidity - strong	<15	<15	<15	<15	<15	<15
- total	26	24	36	42	37	43
Phosphate	0.009	0.022	<0.009	0.022	0.034	0.009
Nitrate	0.31	0.49	0.31	0.49	0.53	0.53
Ammonium	0.025	0.059	0.007	0.078	0.130	0.200
Nitrite	0.030	0.033	<0.017	0.056	0.056	0.059
Cadmium*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0008
Copper*	0.002	0.002	0.003	0.006	0.007	0.011
Lead*	0.007	0.006	0.007	0.019	0.012	0.011
Zinc*	<0.005	<0.005	0.022	0.007	0.006	0.090
Sodium	1.4	1.7	1.4	0.3	0.4	0.4
Sulphate	1.4	1.7	2.2	1.8	2.4	2.8
Potassium	0.1	0.1	0.2	0.1	0.1	0.2
Chloride	2.0	2.3	2.1	0.5	<0.5	0.7
Calcium	0.23	0.40	0.29	0.43	0.56	0.75
Magnesium	0.16	0.20	0.15	0.07	0.10	0.09

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.
+ Some particulate materials present which may contribute to high dissolved ions.

All units are mg/L except: (1) pH in relative units
(2) Acidity in µeq/L

TABLE 4a (Continued)

Date	November 17, 1981; 14:40 to 22:20			November 17, 1981; 22:30 to November 18, 1981; 07:35		
Parameter	Townhouse	Raingauge	Outfall+	Townhouse	Raingauge	Outfall
pH	4.79	4.78	4.92	4.80	4.79	4.92
Acidity - strong	18	19	<15	16	13	<15
- total	46	46	46	46	48	48
Phosphate	0.009	0.012	0.012	0.009	0.012	<0.009
Nitrate	0.84	0.93	1.46	1.15	1.11	1.15
Ammonium	0.100	0.120	0.150	0.083	0.090	0.059
Nitrite	0.033	0.030	0.030	0.023	0.023	0.017
Cadmium*	<0.0005	0.0006	<0.0005	<0.0005	<0.0005	<0.0005
Copper*	0.002	0.003	0.009	0.006	0.003	0.006
Lead*	0.022	0.013	0.018	0.020	0.010	0.016
Zinc*	0.012	0.007	0.021	0.011	0.005	0.023
Sodium	0.4	0.3	0.5	0.3	0.3	0.3
Sulphate	1.5	1.3	2.0	1.4	1.9	2.1
Potassium	0.1	0.1	0.1	0.1	0.1	0.1
Chloride	0.5	<0.5	0.7	0.6	0.5	<0.5
Calcium	0.07	0.11	0.31	0.26	0.11	0.16
Magnesium	0.04	0.06	0.09	0.05	0.05	0.05

Date	November 29, 1981; 19:05 to November 30, 1981; 12:20			November 30, 1981; 12:20 to 14:10		
Parameter	Townhouse+	Raingauge +	Outfall	Townhouse	Raingauge	Outfall
pH	5.19	5.39	4.31	5.07	5.03	4.98
Acidity - strong	<15	<15	20	<15	<15	<15
- total	63	58	93	71	48	50
Phosphate	0.058	0.089	0.025	0.055	0.022	0.018
Nitrate	3.23	1.91	4.30	0.750	0.930	0.710
Ammonium	0.280	0.220	0.500	0.160	0.210	0.170
Nitrite	0.120	0.138	0.112	0.036	0.023	0.023
Cadmium*	<0.0005	<0.0005	0.0007	<0.0005	<0.0005	<0.0005
Copper*	0.007	0.004	0.007	0.002	0.004	0.006
Lead*	0.045	0.017	0.020	0.020	0.010	0.013
Zinc*	0.023	<0.005	0.005	0.012	0.012	0.040
Sodium	1.7	1.6	1.7	0.4	0.3	0.3
Sulphate	3.6	3.6	3.8	3.4	1.7	2.9
Potassium	0.3	0.1	0.2	0.7	<0.1	0.1
Chloride	2.8	2.3	2.6	1.4	<0.5	<0.5
Calcium	1.56	1.40	0.99	0.85	0.21	0.15
Magnesium	0.33	0.26	0.27	0.35	0.07	0.04

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.
+ Some particulate materials present which may contribute to high dissolved ions.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4a (Continued)

Date	November 30, 1981; 14:10 to 18:20			November 30, 1981; 18:25 to 20:45		
Parameter	Townhouse+	Raingauge	Outfall+	Townhouse	Raingauge	Outfall+
pH	4.34	5.11	4.38	4.35	4.99	4.52
Acidity - strong	17	<15	15	17	<15	31
- total	59	43	50	49	46	31
Phosphate	0.022	0.022	0.012	0.012	<0.009	<0.009
Nitrate	0.84	0.34	0.93	0.34	0.93	0.93
Ammonium	0.210	0.200	0.200	0.140	0.160	0.140
Nitrite	0.036	0.030	0.030	0.030	0.026	0.023
Cadmium*	0.0006	<0.0005	0.0006	<0.0005	<0.0005	<0.0005
Copper*	0.010	0.004	0.005	0.004	0.002	0.003
Lead*	0.013	0.013	0.014	0.014	0.006	0.010
Zinc*	0.090	0.090	0.025	0.220	0.020	0.070
Sodium	0.6	0.6	0.7	1.9	2.2	2.5
Sulphate	1.3	1.8	1.8	1.6	1.7	3.0
Potassium	0.1	<0.1	0.1	0.1	0.1	0.1
Chloride	1.0	0.9	1.0	3.3	3.6	4.2
Calcium	0.18	0.11	0.13	0.16	0.09	0.12
Magnesium	0.13	0.07	0.10	0.27	0.24	0.29

Date	November 30, 1981; 20:50 to December 1, 1981; 06:45		
Parameter	Townhouse+	Raingauge	Outfall
pH	5.73	5.02	4.35
Acidity - strong	<15	<15	<6
- total	44	45	52
Phosphate	0.009	0.009	0.009
Nitrate	0.75	0.80	0.75
Ammonium	0.079	0.090	0.068
Nitrite	0.023	0.023	0.020
Cadmium*	0.0007	<0.0005	<0.0005
Copper*	0.004	0.003	0.004
Lead*	0.008	0.007	0.012
Zinc*	0.011	0.018	0.025
Sodium	4.6	4.9	5.6
Sulphate	1.9	2.3	2.6
Potassium	0.2	0.2	0.3
Chloride	7.9	8.3	10.0
Calcium	0.46	0.28	0.45
Magnesium	0.57	0.56	0.61

* Unfiltered - Metals Determined Using HNO_3/HCl Digestion.
+ Some particulate materials present which may contribute to high dissolved ions.

All units are mg/L except: (1) pH in relative units
(2) Acidity in μeq/L

TABLE 4b

SUMMARY OF PRECIPITATION DATA AT THREE SITES

Constituent	Values*											
	Townhouse				Raingauge				Outfall			
	No. of Values	Maximum	Minimum	Mean	No. of Values	Maximum	Minimum	Mean	No. of Values	Maximum	Minimum	Mean
pH	103	7.20	3.05	4.84+	102	6.96	4.02	4.87+	100	6.84	3.95	4.86+
Acidity - strong	77	99	<15	22.4	75	74	<15	21.6	74	110	<15	23
- total	77	219	<15	57	75	146	19	53	74	180	18	68
Ions - calcium	50	3.03	<0.02	0.64	49	2.06	<0.02	0.55	45	1.66	<0.02	0.53
- chloride	54	7.9	<0.5	1.35	53	8.3	<0.5	1.2	52	10	<0.5	1.4
- magnesium	50	0.57	<0.02	0.11	49	0.56	<0.02	0.09	45	0.61	<0.02	0.10
- potassium	54	4	<0.10	0.22	53	0.4	<0.10	0.12	52	5.6	<0.10	0.50
- phosphate (P)	100	0.166	<0.009	0.019	99	0.039	<0.009	0.020	97	1.21	<0.009	0.044
- sodium	54	4.9	0.10	0.84	53	4.9	0.10	0.76	52	5.6	0.10	0.81
- sulfate	50	9.9	0.6	2.36	47	4.6	0.8	2.12	49	7.2	0.7	2.79
Metals - cadmium	67	0.0140	<0.0005	0.0012	66	0.0210	<0.0005	0.0012	64	0.0059	<0.0005	0.0012
- copper	67	0.100	<0.001	0.010	66	0.08	<0.001	0.008	64	0.140	<0.001	0.016
- lead	66	0.400	0.001	0.046	65	0.500	0.001	0.035	64	0.300	0.001	0.029
- zinc	67	0.048	<0.005	0.050	66	1.10	<0.005	0.062	65	0.230	0.005	0.057
Nitrogen (N) - ammonium	100	0.740	<0.007	0.200	100	0.580	0.029	0.178	97	3.75	<0.007	0.221
- nitrate	100	3.23	0.13	0.96	100	3.1	<0.09	0.92	97	5.23	<0.09	0.99
- nitrite	62	0.120	<0.016	0.036	61	0.138	<0.016	0.034	60	0.112	<0.016	0.028

+ Median

* Values are expressed as mg/L except
(1) pH which is as relative units
(2) Acidity in ueq/L

TABLE 4c

PRECIPITATION QUALITY OF OTHER SELECTED BRITISH COLUMBIA LOCATIONS

Parameter	(a) Revelstoke (Sept. 79 to Dec. 80)		(b) Prince Rupert/Terrace (Sept. 80 to Nov. 81)	
	Values*			
	Range	Mean	Range	Mean
Acidity - strong	-	-	<15 - 21	<15**
- total	-	-	24 - 55	39.6
Aluminum	-	-	<0.02 - <0.02	<0.02**
Ammonium	ND - 0.57	0.03**	<0.007 - 0.11	0.022**
Calcium	0.15 - 1.20	0.52	<0.02 - 0.07	0.03**
Chloride	ND - 1.50	0.22**	< 0.5 - 0.5	<0.5**
Fluoride	-	-	<0.04 - <0.04	<0.04**
Magnesium	0.02 - 0.12	0.05	<0.02 - 0.04	0.02**
Nitrate	0.04 - 1.77	0.46	0.09 - 1.11	0.42
pH	4.7 - 6.0	5.5**	4.7 - 5.63	5.03**
Phosphate	-	-	<0.009 - 0.015	<0.009**
Potassium	0.06 - 0.29	0.14	<0.009- 0.1	<0.1**
Sodium	ND - 0.8	0.1**	<0.1 - 0.5	0.2**
Specific Conductance	4.1 - 26.8	8.8	-	-
Sulphate	0.4 - 3.7	0.94	0.5 - 1.9	0.96

ND - Not detectable.

* - All values are mg/L except: (1) pH
(2) Specific conductance as us/cm.
(3) Acidity as µeq/L

** - Median since some recorded values (except for pH) were below detection limit.

(a) - Station data were continuously collected samples during approximately one month periods (16 samples).

(b) - Station located in the Skeena Valley, approximately halfway between Terrace and Prince Rupert. Seven samples were collected over specific events.

TABLE 5a

DUSTFALL DATA
COMPARISON OF THREE SITES ON A SAMPLE BASIS

(tonnes/km^2/mo)

Date	October 22, 1980 to November 7, 1980			November 7, 1980 to November 21, 1980		
Parameters	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
Arsenic - Total	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007
- Sol.	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007
- Insol.	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007
Cadmium - Total	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035
- Sol.	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035
- Insol.	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035
Copper - Total	0.00280	0.00455	0.00140	0.00070	0.00175	0.00140
- Sol.	0.00245	0.00175	0.00105	<0.00035	0.00140	0.00140
- Insol.	0.00035	0.00280	0.00035	0.00070	<0.00035	<0.00035
Lead - Total	0.00280	0.00105	0.00070	0.00280	0.00175	0.00105
- Sol.	0.00245	0.00070	<0.00035	0.00280	0.00175	0.00105
- Insol.	0.00035	0.00035	0.00070	<0.00035	<0.00035	-
Mercury - Sol.	<0.000007	<0.000007	<0.000007	<0.000007	<0.000007	<0.000007
- Insol.	0.000021	0.000070	0.000035	<0.000007	<0.000007	0.000014
Zinc - Total	0.01926	0.01366	0.00666	0.00315	0.00420	0.01506
- Sol.	0.01891	0.01296	0.00596	0.00315	0.00350	0.01471
- Insol.	0.00035	0.00070	0.00070	<0.00035	0.00070	0.00035
Particulate - Total	2.98	8.02	10.60	1.29	2.00	7.50
- Sol.	2.10	1.82	2.77	1.29	2.00	4.59
- Insol.	0.88	6.20	7.80	<0.18	<0.18	2.91
- Sol. Ash	1.44	0.84	1.16	0.53	0.81	1.72
- Insol. Ash	0.25	0.39	0.25	<0.18	<0.18	0.35
- Combined	1.30	6.80	9.18	-	-	-
Chloride	-	-	-	0.210	0.210	0.210
Fluoride	-	-	-	<0.007	<0.007	<0.007
Sodium	-	-	-	0.14	0.10	0.14

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	November 21, 1980 to December 10, 1980			December 10, 1980 to December 21, 1980		
Parameters	Townhouse	Raingauge	Outfall*	Townhouse	Raingauge	Outfall
Arsenic - Total	<0.0007	<0.0007		<0.0007	-	0.0007
- Sol.	<0.0007	<0.0007		<0.0007	0.0007	0.0007
- Insol.	<0.0007	<0.0007		<0.0007	<0.0007	<0.0007
Cadmium - Total	<0.00035	<0.00035		<0.00035	<0.00035	<0.00035
- Sol.	<0.00035	<0.00035		<0.00035	<0.00035	<0.00035
- Insol.	<0.00035	<0.00035		<0.00035	<0.00035	<0.00035
Copper - Total	<0.00035	<0.00035		0.00250	0.00245	0.00035
- Sol.	<0.00035	<0.00035		0.00210	0.00210	<0.00035
- Insol.	<0.00035	<0.00035		0.00035	0.00035	<0.00035
Lead - Total	0.00250	0.00175		0.00390	0.00210	0.00140
- Sol.	0.00250	0.01400		0.00280	0.00180	0.00070
- Insol.	<0.00035	0.00350		0.00110	0.00035	0.00070
Mercury - Sol.	<0.000007	<0.000007	<0.000007	0.000018	0.000025	0.000039
- Insol.	0.000042	0.000042	<0.000007	<0.000007	<0.000007	<0.000007
Zinc - Total	0.00210	0.00140		0.00700	0.00390	0.01000
- Sol.	0.00180	0.00140		0.00670	0.00390	0.01000
- Insol.	0.00035	<0.00035		0.00035	<0.00035	<0.00035
Particulate - Total	3.26	1.05		2.52	1.51	2.00
- Sol.	2.10	0.38		1.12	1.12	1.19
- Insol.	1.16	0.18		1.40	0.39	0.81
- Sol. Ash	0.91	0.28		0.46	0.46	0.67
- Insol. Ash	0.39	<0.18		1.40	0.32	<0.18
- Combined	-	-		-	-	-
Chloride	0.320	0.070		0.210	0.460	0.250
Fluoride	<0.007	<0.007		<0.007	<0.007	<0.007
Sodium	0.11	0.11		0.11	0.11	0.14

* Vandalized

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	December 27, 1980 to January 27, 1981			January 27, 1981 to February 16, 1981		
Parameters	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
Arsenic - Total	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007
- Sol.	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007
- Insol.	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007
Cadmium - Total	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035
- Sol.	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035
- Insol.	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035
Copper - Total	0.00035	0.00110	0.00035	0.00035	0.00175	<0.00035
- Sol.	<0.00035	0.00070	<0.00035	<0.00035	0.00140	<0.00035
- Insol.	0.00035	0.00035	0.00035	0.00035	0.00035	<0.00035
Lead - Total	0.00360	0.00110	0.00140	0.00525	0.00175	0.00210
- Sol.	0.00216	0.00070	0.00070	0.00280	0.00105	0.00140
- Insol.	0.00140	0.00035	0.00070	0.00250	0.00070	0.00070
Mercury - Sol.	<0.000007	0.000011	<0.000007	<0.000007	<0.000007	<0.000007
- Insol.	<0.000007	<0.000007	<0.000007	<0.000007	0.000014	<0.000007
Zinc - Total	0.00385	0.00630	0.00910	0.00420	0.00315	0.00490
- Sol.	0.00385	0.00630	0.00880	0.00035	0.00280	0.00455
- Insol.	<0.00035	<0.00035	0.00035	0.00007	0.00035	0.00035
Particulate - Total	-	1.23	-	3.22	2.42	4.03
- Sol.	-	0.70	-	1.54	0.98	1.65
- Insol.	-	0.53	-	1.68	1.44	2.38
- Sol. Ash	-	0.42	-	0.70	<0.18	0.95
- Insol. Ash	-	0.42	-	1.05	0.18	0.46
- Combined	-	-	-	-	-	-
Chloride	0.108	0.140	0.175	0.140	0.105	0.140
Fluoride	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Sodium	<0.07	<0.07	<0.07	0.07	0.07	0.07

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	February 16, 1981 to February 25, 1981			February 17, 1981 to March 17, 1981		
Parameters	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
Arsenic - Total	-	-	-	0.0007	0.0007	<0.0007
- Sol.	-	-	-	0.0007	0.0007	<0.0007
- Insol.	-	-	-	<0.0007	<0.0007	<0.0007
Cadmium - Total	-	-	-	<0.00035	<0.00035	<0.00035
- Sol.	-	-	-	<0.00035	<0.00035	<0.00035
- Insol.	-	-	-	<0.00035	<0.00035	<0.00035
Copper - Total	-	-	-	0.00070	<0.00035	0.00035
- Sol.	-	-	-	<0.00035	<0.00035	<0.00035
- Insol.	-	-	-	0.00070	<0.00035	0.00035
Lead - Total	-	-	-	0.00385	0.0018	0.00245
- Sol.	-	-	-	0.00105	0.00004	0.00070
- Insol.	-	-	-	0.00230	0.00014	0.00175
Mercury - Sol.	0.000011	0.000018	0.000018	0.000007	0.000007	0.000011
- Insol.	-	-	-	<0.000007	<0.000007	<0.000007
Zinc - Total	-	-	-	0.00245	0.00175	0.00280
- Sol.	-	-	-	0.00210	0.00140	0.00210
- Insol.	-	-	-	0.00035	0.00035	0.00070
Particulate - Total	-	-	-	4.31	5.15	3.61
- Sol.	-	-	-	1.86	3.22	1.40
- Insol.	-	-	-	2.45	1.93	2.21
- Sol. Ash	-	-	-	0.84	1.23	0.67
- Insol. Ash	-	-	-	0.91	0.32	0.46
- Combined	-	-	-	-	-	-
Chloride	-	-	-	0.2100	0.2450	0.2100
Fluoride	-	-	-	<0.007	<0.007	<0.007
Sodium	-	-	-	0.1400	0.140	0.105

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	March 17, 1981 to March 31, 1981			March 31, 1981 to April 22, 1981		
Parameters	Townhouse	Raingauge	Outfall	Townhouse*	Raingauge*	Outfall*
Arsenic - Total	<0.0007	<0.0007	<0.0007	-	-	-
- Sol.	<0.0007	<0.0007	<0.0007	-	-	-
- Insol.	<0.0007	<0.0007	<0.0007	-	-	-
Cadmium - Total	<0.00035	<0.00035	<0.00035	-	-	-
- Sol.	<0.00035	<0.00035	<0.00035	-	-	-
- Insol.	<0.00070	<0.00035	<0.00035	-	-	-
Copper - Total	0.00070	0.00175	0.00420	-	-	-
- Sol.	<0.00035	0.00140	0.00420	-	-	-
- Insol.	0.00070	0.00035	<0.00035	-	-	-
Lead - Total	0.00350	0.00175	0.00175	-	-	-
- Sol.	0.00105	0.00070	0.00105	-	-	-
- Insol.	0.00245	0.00105	0.00070	-	-	-
Mercury - Sol.	0.000035	0.000007	0.000007	0.000025	0.000025	0.000035
- Insol.	0.000133	<0.000007	<0.000007	0.000007	0.000011	<0.000007
Zinc - Total	0.00980	0.00490	0.01436	-	-	-
- Sol.	0.00980	0.00455	0.01436	-	-	-
- Insol.	<0.00070	0.00035	<0.00035	-	-	-
Particulate - Total	3.71	2.91	5.08	-	-	-
- Sol.	1.72	1.26	3.22	-	-	-
- Insol.	2.00	1.65	1.86	-	-	-
- Sol. Ash	0.63	0.42	1.09	-	-	-
- Insol. Ash	0.98	0.56	0.63	-	-	-
- Combined	-	-	-	-	-	-
Chloride	0.3850	0.2450	0.2800	-	-	-
Fluoride	<0.0070	<0.0070	<0.0070	-	-	-
Sodium	0.2100	0.1750	0.2450	-	-	-

* For mercury only

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	March 31, 1981 to April 28, 1981			April 28, 1981 to May 28, 1981		
Parameters	Townhouse*	Raingauge*	Outfall*	Townhouse	Raingauge	Outfall
Arsenic - Total	<0.0007	<0.0007	<0.0007	-	-	-
- Sol.	<0.0007	<0.0007	<0.0007	-	-	-
- Insol.	<0.0007	<0.0007	<0.0007	-	-	-
Cadmium - Total	<0.00035	<0.00035	<0.00035	-	-	-
- Sol.	<0.00035	<0.00035	<0.00035	-	-	-
- Insol.	<0.00035	<0.00035	<0.00035	-	-	-
Copper - Total	<0.00035	<0.00035	<0.00035	0.00140	0.00035	0.00035
- Sol.	<0.00035	<0.00035	<0.00035	0.00070	<0.00035	<0.00035
- Insol.	<0.00035	<0.00035	<0.00035	0.00070	0.00035	0.00035
Lead - Total	0.0049	0.0021	0.0007	0.0035	0.0018	0.0014
- Sol.	0.0042	0.0014	0.0004	0.0025	0.0011	0.0007
- Insol.	0.0007	0.0007	0.0004	0.0011	0.0007	0.0007
Mercury - Sol.	-	-	-	0.000007+	0.000007+	0.000007+
- Insol.	-	-	-	0.000007+	0.000007+	0.000007+
Zinc - Total	0.00245	0.00210	0.00140	0.00350	0.00385	0.00530
- Sol.	0.00245	0.00175	0.00140	0.00320	0.00245	0.00490
- Insol.	<0.00035	0.00035	<0.00035	0.00030	0.00140	0.00040
Particulate - Total	3.29	3.05	4.90	2.45	2.00	-
- Sol.	1.86	2.07	2.21	0.91	0.77	-
- Insol.	1.44	0.98	2.70	1.54	1.23	-
- Sol. Ash	0.49	0.46	1.23	0.70	0.56	-
- Insol. Ash	1.02	0.46	0.46	0.84	0.49	-
- Combined	-	-	-	-	-	-
Chloride	0.210	0.210	0.105	<0.070	<0.070	<0.070
Fluoride	<0.007	<0.007	<0.007	<0.007	<0.007	<0.0007
Sodium	0.105	0.105	0.105	<0.070	<0.070	<0.070

* See mercury values on previous page
+ Mercury values for period April 22 to May 25

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	May 28, 1981 to June 28, 1981			June 28, 1981 to July 21, 1981		
Parameters	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
Arsenic - Total	<0.0007	<0.0007	<0.0007	-	-	-
- Sol.	<0.0007	<0.0007	<0.0007	-	-	-
- Insol.	<0.0007	<0.0007	<0.0007	-	-	-
Cadmium - Total	<0.00035	<0.00035	<0.00035	-	-	-
- Sol.	<0.00035	<0.00035	<0.00035	-	-	-
- Insol.	<0.00035	<0.00035	<0.00035	-	-	-
Copper - Total	0.00070	0.00210	<0.00035	0.00035	0.00035	-
- Sol.	0.00070	0.00140	<0.00035	<0.00035	<0.00035	-
- Insol.	<0.00035	0.00070	<0.00035	0.00035	0.00035	-
Lead - Total	0.00560	0.00140	0.00175	0.00280	0.00140	-
- Sol.	0.00460	0.00070	0.00105	0.00210	0.00070	-
- Insol.	0.00110	0.00070	0.00070	0.00070	0.00070	-
Mercury - Sol.	<0.000007*	<0.000007*	<0.000007*	0.000011+	0.000011+	<0.000007+
- Insol.	<0.000007*	<0.000007*	<0.000007*	<0.000007+	<0.000007+	<0.000007+
Zinc - Total	0.00350	0.00245	0.00175	0.00070	0.000701	-
- Sol.	0.00230	0.00175	0.00140	<0.00035	<0.00035	-
- Insol.	0.00070	0.00070	0.00035	0.00070	0.00070	-
Particulate - Total	2.00	1.75	2.77	1.44	2.21	-
- Sol.	1.23	0.70	1.37	0.25	1.44	-
- Insol.	0.77	1.05	1.40	1.19	0.77	-
- Sol. Ash	0.53	0.63	0.70	0.21	0.39	-
- Insol. Ash	0.46	0.67	0.35	0.95	0.56	-
- Combined						-
Chloride	0.140	0.140	0.175	0.070	0.210	-
Fluoride	<0.007	<0.007	<0.007	<0.007	<0.007	-
Sodium	<0.007	<0.070	<0.070	<0.070	<0.070	-

* Mercury analysis for period May 25 to June 24
+ Mercury analysis for period June 24 to July 21

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	July 21, 1981 to August 5, 1981			August 5, 1981 to September 4, 1981		
Parameters	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
Arsenic - Total	-	-	-	-	-	-
- Sol.	-	-	-	-	-	-
- Insol.	-	-	-	-	-	-
Cadmium - Total	-	-	-	-	-	-
- Sol.	-	-	-	-	-	-
- Insol.	-	-	-	-	-	-
Copper - Total	0.00035	0.00070	0.00035	0.00070	-	-
- Sol.	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035	<0.00035
- Insol.	0.00035	0.00070	0.00035	0.00070	-	-
Lead - Total	0.00315	0.00105	0.00070	0.00600	0.00140	0.00175
- Sol.	0.00140	0.00035	<0.00035	0.00210	0.00035	0.00105
- Insol.	0.00175	0.00070	0.00070	0.00390	0.00105	0.00070
Mercury - Sol.	<0.000007	<0.000007		0.000011	-	-
- Insol.	<0.000007	<0.000007		<0.000007	-	-
Zinc - Total	0.00490	0.00420	0.00245	0.00455	0.00420	0.00350
- Sol.	0.00420	0.00315	0.00105	0.00315	0.00245	0.00035
- Insol.	0.00070	0.00105	0.00140	0.00140	0.00175	0.00105
Particulate - Total	3.57	0.49	1.51	2.38	2.00	2.87
- Sol.	1.51	<0.18	<0.18	0.91	0.81	1.09
- Insol.	2.07	0.49	1.51	1.47	1.19	1.79
- Sol. Ash	<0.18	<0.18	<0.18	0.63	0.46	0.67
- Insol. Ash	0.56	0.18	0.46	0.98	0.74	1.02
- Combined	-	-	-	-	-	-
Chloride	0.210	<0.070	<0.070	<0.070	<0.070	<0.070
Fluoride	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Sodium	<0.070	<0.070	<0.070	<0.070	<0.070	<0.070

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	September 4, 1981 to October 1, 1981			October 1, 1981 to October 30, 1981		
Parameters	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
Arsenic - Total	-	-	-	-	-	-
- Sol.	-	-	-	-	-	-
- Insol.	-	-	-	-	-	-
Cadmium - Total	-	-	-	-	-	-
- Sol.	-	-	-	-	-	-
- Insol.	-	-	-	-	-	-
Copper - Total	0.00035	0.00140	0.00245	0.00070	0.00035	0.00035
- Sol.	<0.00035	0.00105	0.00140	<0.00035	<0.00035	<0.00035
- Insol.	0.00035	0.00035	0.00105	0.00070	0.00035	0.00035
Lead - Total	0.00175	0.00140	0.00140	0.00701	0.00245	0.00175
- Sol.	0.00070	0.00035	0.00035	0.00035	0.00070	<0.00035
- Insol.	0.00105	0.00105	0.00105	0.00666	0.00175	0.00175
Mercury - Sol.	<0.000007	<0.00007	0.000007	0.000028	0.000014	0.000021
- Insol.	<0.000007	<0.00007	<0.000007	-	-	-
Zinc - Total	0.00420	0.00666	0.00525	0.00420	0.00280	0.00245
- Sol.	0.00350	0.00560	0.00350	0.00105	0.00210	<0.00035
- Insol.	0.00070	0.00105	0.00175	0.00315	0.00070	0.00245
Particulate - Total	2.49	2.52	3.40	4.27	3.36	4.69
- Sol.	1.02	1.23	1.68	2.17	2.00	2.28
- Insol.	1.47	1.30	1.72	2.10	1.37	2.42
- Sol. Ash	0.81	0.91	0.81	0.70	0.60	1.09
- Insol. Ash	0.88	0.56	0.53	0.74	0.39	0.35
- Combined	-	-	-	-	-	-
Chloride	0.420	0.140	0.245	0.280	0.210	0.175
Fluoride	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Sodium	0.1051	0.1051	0.1051	0.0701	0.0701	0.0701

TABLE 5a (Continued)
(tonnes/km^2/mo)

Date	October 30, 1981 to November 15, 1981			November 15, 1981 to November 30, 1981		
Parameters	Townhouse	Raingauge	Outfall	Townhouse	Raingauge	Outfall
Arsenic - Total	-	-	-	-	-	-
- Sol.	-	-	-	-	-	-
- Insol.	-	-	-	-	-	-
Cadmium - Total	<0.00035	<0.00035	<0.00035	-	-	-
- Sol.	<0.00035	<0.00035	<0.00035	-	-	-
- Insol.	<0.00035	<0.00035	<0.00035	-	-	-
Copper - Total	0.00455	0.00245	0.00140	0.00035	0.00035	0.00035
- Sol.	0.00315	0.00175	0.00105	<0.00035	<0.00035	<0.00035
- Insol.	0.00140	0.00070	0.00035	0.00035	0.00035	0.00035
Lead - Total	0.00490	0.00210	0.00210	0.00455	0.00385	0.00175
- Sol.	0.00070	0.00035	0.00035	0.00070	0.00070	<0.00035
- Insol.	0.00420	0.00175	0.00175	0.00385	0.00315	0.00175
Mercury - Sol.	<0.000007	<0.000007	<0.000007	<0.000007	<0.000007	<0.000007
- Insol.	-	-	-	-	-	-
Zinc - Total	0.00490	0.00315	0.00525	0.00315	0.00140	0.00245
- Sol.	0.00350	0.00175	0.00175	0.00210	<0.00035	0.00140
- Insol.	0.00140	0.00140	0.00350	0.00105	0.00140	0.00105
Particulate - Total	11.07	4.34	13.45	4.59	4.94	5.92
- Sol.	7.88	3.15	10.02	2.70	3.40	3.75
- Insol.	3.19	1.19	3.43	1.89	1.54	2.17
- Sol. Ash	1.19	0.84	2.91	1.75	1.86	1.54
- Insol. Ash	0.74	0.49	0.46	0.67	0.32	0.49
- Combined	-	-	-	-	-	-
Chloride	0.455	0.490	0.701	0.771	0.315	0.280
Fluoride	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Sodium	0.2452	0.2452	0.2101	0.2802	0.2101	0.1751

TABLE 5b

SUMMARY OF DUSTFALL DATA AT THREE SITES

Constituent	Values*											
	Townhouse				Raingauge				Outfall			
	No. of Values	Maximum	Minimum	Mean	No. of Values	Maximum	Minimum	Mean	No. of Values	Maximum	Minimum	Mean
Ions: chloride	17	0.77	<0.07	0.25	17	0.49	<0.07	0.20	15	0.70	<0.07	0.21
: fluoride	17	<0.007	<0.007	<0.007	17	<0.007	<0.007	<0.007	15	<0.007	<0.007	<0.007
: sodium	17	0.28	<0.07	0.12	17	0.25	<0.07	0.11	15	0.25	<0.07	0.11
Metals:												
:Arsenic - total	9	0.0007	<0.0007	<0.0007	8	0.0007	<0.0007	<0.0007	8	0.0007	<0.0007	<0.0007
- soluble	9	0.0007	<0.0007	<0.0007	9	0.0007	<0.0007	<0.0007	8	0.0007	<0.0007	<0.0007
- insoluble	9	<0.0007	<0.0007	<0.0007	9	<0.0007	<0.0007	<0.0007	8	<0.0007	<0.0007	<0.0007
:Cadmium - total	10	<0.0004	<0.0004	<0.0004	10	<0.0004	<0.0004	<0.0004	9	<0.0004	<0.0004	<0.0004
- soluble	10	<0.0004	<0.0004	<0.0004	10	<0.0004	<0.0004	<0.0004	9	<0.0004	<0.0004	<0.0004
- insoluble	10	<0.0004	<0.0004	<0.0004	10	<0.0004	<0.0004	<0.0004	9	<0.0004	<0.0004	<0.0004
:Copper - total	17	0.0046	<0.0004	0.0009	16	0.0025	<0.0004	0.0011	14	0.0052	<0.0004	0.0010
- soluble	17	0.0032	<0.0004	0.0007	17	0.0021	<0.0004	0.0008	15	0.0052	<0.0004	0.0008
- insoluble	17	0.0014	<0.0004	0.0005	16	0.0007	<0.0004	<0.0004	14	0.0011	<0.0004	0.0004
:Lead - total	17	0.0070	0.0018	0.0041	17	0.0039	0.0011	0.0018	15	0.0025	0.0007	0.0016
- soluble	17	0.0046	0.0004	0.0020	17	0.0018	0.0004	0.0008	15	0.0013	<0.0004	0.0007
- insoluble	17	0.0067	<0.0004	0.0020	17	0.0032	<0.0004	0.0010	15	0.0017	<0.0004	0.0011
:Mercury - total	2	0.00003	<0.00001	0.00002	2	0.00004	0.00001	0.00002	-	-	-	-
- soluble	5	0.00003	<0.00001	0.00002	5	0.00002	<0.00001	0.00001	4	0.00004	0.00001	0.00002
- insoluble	2	<0.00001	<0.00001	<0.00001	2	<0.00001	<0.00001	<0.00001	1	0.00001	0.00001	0.00001
:Zinc - total	17	0.0098	0.0007	0.0040	17	0.0067	0.0007	0.0034	15	0.0150	0.0014	0.0057
- soluble	17	0.0098	<0.0004	0.0004	17	0.0063	<0.0004	0.0027	15	0.0147	<0.0004	0.0049
- insoluble	17	0.0032	<0.0004	0.0008	17	0.0018	<0.0004	0.0008	15	0.0035	<0.0004	0.0010
Particulate:												
- total	16	11.07	1.30	3.49	17	5.15	0.49	2.52	13	13.45	1.51	4.75
- soluble	16	7.88	0.25	1.88	17	3.40	<0.18	1.52	13	10.02	<0.18	2.66
- insoluble	16	3.19	<0.18	1.62	17	1.93	<0.18	1.02	13	3.43	0.81	2.10
- soluble ash	16	1.75	<0.18	0.70	17	1.86	<0.18	0.63	13	2.91	<0.18	1.09
- insoluble ash	16	1.40	<0.18	0.79	17	0.74	<0.18	0.41	13	1.02	<0.18	0.47

* Values are expressed as tonnes/km^2/mo.

TABLE 6

MEASURED SURFACE SOIL MOISTURE CONTENT (%)

Date	Nov. 26/80	Nov. 27/80	Dec. 1/80	Dec. 9/80	Dec. 10/80	Dec. 12/80	Dec. 14/80
Sample 1	35.11	37.24	39.03	38.44	25.52	22.20	29.29
Sample 2	-	36.82	35.30	27.44	25.10	24.03	32.16
Mean	35.11	37.03	37.17	32.94	25.31	23.12	30.73
Date	Dec. 17/80	Dec. 23/80	Jan. 6/81	Jan. 20/81	Jan. 21/81	Jan. 26/81	Jan. 28/81
Sample 1	31.13	25.17	32.25	51.68	30.86	28.38	53.32
Sample 2	33.18	29.21	32.68	38.56	-	34.11	57.97
Mean	32.16	27.19	32.47	45.12	30.86	31.25	55.65
Date	Jan. 29/81	Feb. 16/81	Feb. 17/81	Feb. 19/81	Feb. 23/81	Feb. 25/81	Feb. 27/81
Sample 1	25.42	38.55	33.99	35.99	31.68	36.34	28.44
Sample 2	39.94	42.47	46.21	32.82	29.69	40.36	28.76
Mean	32.68	40.51	39.60	34.41	30.69	38.35	28.60
Date	Mar. 3/81	Mar. 6/81	Mar. 10/81	Mar. 17/81	Mar. 23/81	Mar. 25/81	Mar. 29/81
Sample 1	35.60	32.06	29.32	33.34	30.33	30.94	31.88
Sample 2	41.22	30.33	30.21	33.44	29.35	25.69	32.40
Mean	38.41	31.20	29.77	33.39	29.84	28.32	32.14
Date	Mar. 31/81	Apr. 6/81	Apr. 9/81	Apr. 15/81	Apr. 22/81	Apr. 28/81	May 5/81
Sample 1	40.73	30.86	30.65	35.15	30.55	34.35	33.63
Sample 2	42.86	35.75	35.79	36.83	36.31	33.06	35.31
Mean	41.80	33.31	33.22	35.99	33.43	33.71	34.47
Date	May 12/81	May 14/81	June 16/81	June 18/81	June 25/81	July 7/81	July 22/81
Sample 1	31.29	35.98	46.52	35.81	33.59	31.8	36.1
Sample 2	30.22	32.91	33.93	32.98	37.67	28.4	33.9
Mean	30.76	34.44	40.23	34.40	35.23	30.1	35.0

TABLE 6 (Continued)

MEASURED SURFACE SOIL MOISTURE CONTENT (%)

Date	July 27/81	Aug. 5/81	Aug. 12/81	Aug. 19/81	Sept. 1/81	Sept. 18/81	Sept. 21/81
Sample 1	25.7	30.0	21.9	12.0	33.5	12.7	26.7
Sample 2	24.8	29.6	20.5	16.8	32.0	11.5	23.8
Mean	25.3	29.8	21.2	14.4	32.8	12.1	25.3

Date	Sept. 29/81	Oct. 5/81	Oct. 6/81	Oct. 15/81	Oct. 19/81	Nov. 5/81	Nov. 8/81
Sample 1	55.2	33.8	28.5	25.8	36.5	24.5	34.9
Sample 2	31.8	32.6	30.4	32.1	37.3	23.7	35.3
Mean	43.5	33.2	29.5	29.0	36.9	24.1	35.1

Date	Nov. 13/81	Nov. 16/81	Nov. 29/81
Sample 1	34.0	47.3	36.0
Sample 2	39.7	39.8	37.2
Mean	39.9	43.6	36.6

TABLE 7

MEASURED RUNOFF AND INFILTRATION (cm)

Oct. 21/80		Oct. 27/80		Nov. 4/80	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.60	0.00	1.05	0.00	5.34
0.00	0.58	0.00	1.06	0.00	5.23

Nov. 5/80		Nov. 6/80		Nov. 8/80	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	1.79	0.00	1.11	0.00	4.53
0.00	1.73	0.00	0.58	0.00	0.95

Nov. 10/80		Nov. 11/80		Nov. 18/80	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.46	-
0.00	-	0.00	-	0.45	-
0.00	1.11	0.00	0.00	0.00	3.72
0.00	0.16	0.00	0.08	0.00	0.96

Nov. 21/80		Nov. 26/80		Nov. 27/80	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.11	-	0.00	-	0.00	-
0.10	-	0.00	-	0.00	-
0.00	5.12	0.00	2.53	0.07	2.66
0.00	1.89	0.00	2.10	0.02	1.89

Nov. 28/80		Nov. 30/80		Dec. 1/80	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.18	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.31	0.92	3.12	0.00	0.87
0.00	1.11	0.00	0.64	0.00	1.20

TABLE 7(Continued)

Dec. 10/80		Dec. 12/80		Dec. 14/80	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.10	-	0.00	-
0.21	2.50	0.00	2.48	0.00	1.43
0.00	4.86	0.00	3.58	0.00	1.36

Dec. 15/80		Dec. 16/80		Dec. 22/80	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.01	-
0.00	0.69	0.00	0.05	0.00	5.41
0.00	0.72	0.00	0.32	0.22	4.69

Dec. 23/80		Dec. 27/80		Dec. 31/80	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	1.84	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.76	0.00	7.65	0.00	2.23
0.10	0.73	1.11	3.54	0.12	1.32

Jan. 6/81		Jan. 8/81		Jan. 10/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.27	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.07	0.00	0.04	0.00	0.64
0.00	0.43	0.00	0.23	0.04	0.26

Jan. 13/81		Jan. 19/81		Jan. 20/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.05	0.00	0.95	0.00	0.17
0.00	0.33	0.00	0.40	0.00	0.19

TABLE 7 (Continued)

Jan. 22/81		Jan. 26/81		Jan. 27/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.53	0.00	1.03	0.00	0.48
0.09	0.13	0.11	0.49	0.00	0.12

Jan. 30/81		Jan. 31/81		Feb. 16/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.16	-	0.00	-	0.00	-
0.08	-	0.00	-	0.00	-
0.00	1.89	0.00	0.12	0.00	7.89
0.31	0.36	0.00	0.18	0.00	7.69

Feb. 17/81		Feb. 18/81		Feb. 19/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.90	0.00	2.33	0.00	1.67
0.03	1.47	0.55	1.94	0.42	1.24

Feb. 23/81		Feb. 26/81		March 3/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.01	-	0.00	-	0.00	-
0.01	-	0.00	-	0.00	-
0.00	1.98	0.00	1.43	0.00	3.05
0.23	1.85	0.00	0.68	1.39	2.71

March 5/81		March 10/81		March 17/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.31	0.00	0.30	0.00	0.87
0.00	0.24	0.00	0.27	0.90	0.94

TABLE 7 (Continued)

March 25/81		April 1/81		April 3/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.05	-	0.01	-
0.00	1.02	0.00	4.89	0.00	0.96
0.01	0.51	1.31	2.89	0.21	0.70

April 5/81		April 6/81		April 9/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.03	-	0.00	-	0.00	-
0.05	-	0.00	-	0.00	-
0.00	1.65	0.00	0.72	0.00	1.38
0.16	0.67	0.02	0.32	0.03	0.67

April 13/81		April 23/81		April 28/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.04	-	0.00	-	0.00	-
0.03	-	0.10	-	0.04	-
0.00	1.36	0.00	5.13	0.00	2.30
0.02	0.57	3.34	1.09	0.98	0.39

April 29/81		May 1/81		May 4/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.05	-	0.00	-	0.00	-
0.07	-	0.00	-	0.00	-
0.00	0.56	0.00	0.66	0.00	1.16
0.12	0.01	0.03	0.11	3.55	0.22

May 5/81		May 6/81		May 11/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.86	0.00	0.43	0.00	1.05
0.00	0.07	0.09	0.07	0.06	0.16

TABLE 7 (Continued)

May 13/81		May 14/81		May 15/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.48	0.00	0.18	0.00	0.23
0.03	0.10	0.00	0.04	0.32	0.07

May 17/81		May 19/81		May 20/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.52	0.00	0.35	0.00	0.13
0.02	0.13	0.39	0.12	0.00	0.03

May 26/81		June 1/81		June 4/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.01	-	0.00	-	0.00	-
0.06	-	0.00	-	0.00	-
0.00	0.81	0.00	0.89	0.00	0.43
1.52	0.33	0.00	0.25	0.00	0.08

June 8/81		June 12/81		June 16/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	2.31	0.00	2.02	0.00	4.07
0.78	0.18	2.89	0.16	2.07	0.26

June 19/81		June 22/81		June 25/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	1.43	0.00	1.51	0.00	0.76
2.45	0.17	0.55	0.11	0.94	0.10

TABLE 7 (Continued)

June 27/81		July 1/81		July 7/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.32	0.00	0.57	0.00	0.73
0.00	0.06	0.06	0.14	2.89	0.28

July 8/81		July 10/81		July 21/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.23	0.00	0.40	0.00	1.09
0.03	0.01	0.00	0.04	0.00	0.00

July 27/81		July 29/81		Aug. 4/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.26	0.00	0.06	0.00	0.06
0.00	0.11	0.00	0.06	0.00	0.03

Aug. 26/81		Sept. 1/81		Sept. 17/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.01	-	0.00	-
0.00	-	0.01	-	0.00	-
0.00	0.12	0.00	0.13	0.00	0.31
0.00	0.00	0.00	0.00	0.00	0.00

Sept. 21/81		Sept. 28/81		Oct. 1/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.00	0.07	0.01	0.28	5.44	0.20
0.00	0.00	0.00	0.00	4.16	0.00

TABLE 7 (Continued)

Oct. 4/81		Oct. 6/81		Oct. 7/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.41	0.10	0.00	1.48	1.64	0.14
0.37	0.00	0.00	1.30	1.59	0.00

Oct. 13/81		Oct. 20/81		Oct. 27/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.47	0.27	0.00	0.17	0.76	0.21
2.48	0.00	0.00	0.00	0.84	0.00

Oct. 28/81		Oct. 30/81		Nov. 4/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.88	0.00	0.00	0.14	11.11	0.24
0.79	0.00	0.00	0.00	7.78	0.09

Nov. 13/81		Nov. 16/81		Nov. 18/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
0.29	0.30	0.00	2.14	2.58	0.18
3.08	0.00	0.00	1.13	1.19	0.00

Nov. 26/81		Nov. 29/81		Dec. 2/81	
Runoff	Infiltration	Runoff	Infiltration	Runoff	Infiltration
0.00	-	0.00	-	0.00	-
0.00	-	0.00	-	0.00	-
3.31	0.35	0.02	0.14	7.99	0.31
6.72	0.00	0.06	0.00	7.76	0.00

TABLE 7 (Continued)

Dec. 14/81		Total	
Runoff	Infiltration	Runoff	Infiltration
0.00	-		-
0.00	-		-
0.62	0.43	36.73	136.32
0.83	1.37	68.16	78.62

NOTES TO TABLE:

The two runoff columns were not examined with respect to soil consistency. Data for these two columns were listed in this table as the first and second lines.

Soil columns were examined on December 14, 1981;

#1 (listed consistently in this table as the third line) - Large quantities of sand and gravel, some rocks of approximately 4 inch diameter (characteristic throughout full height of column).

#2 (listed consistently in this table as the fourth line) - Layer of clay approximately 4 inches thick underlaid topsoil - Lots of organic material throughout column height - Smaller gradation of sand and gravel than found in Column #1.

TABLE 3

TOTAL DAILY STORMWATER FLOWS
(m^3/day)

Day of Month	1980		1981											
	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1		530.2	103.7	110.3	70.6	168.3	145.3	86.1	85.2	37.7	192.4	3663.0	1076.0	2783.3
2		570.2	85.8	106.0	88.6	436.3	217.5	137.5	114.6	37.7	56.6	351.2	199.7	1549.1
3		245.4	85.8	107.2	1595.0	112.5	1503.3	133.0	98.5	50.0	56.6	141.8	130.0	667.1+
4		138.8	89.7	101.3	118.4	1053.7	623.7	108.0	93.6	50.0	119.9	137.0	106.0	0.0+
5		118.9	98.0	101.8	85.7	1260.3	137.9	907.7	94.0	50.0	110.3	818.6	101.8	0.0+
6		118.9	106.0	101.8	85.7	109.3	151.2	77.0	1130.5	50.0	110.3	1148.6	144.5	0.0+
7		118.9	101.8	97.7	242.5	93.6	650.4	65.8	664.6	50.0	110.3	821.9	155.8	105.7+
8		112.3	106.0	97.7	112.9	904.6	153.7	535.9	60.4	50.0	257.7	1426.2	160.7	264.7
9		999.3	341.2	97.7	110.3	98.0	146.3	332.0	37.7	97.7	110.3	952.8	175.6	1547.4
10		1363.3	106.0	89.7	110.3	89.7	161.5	475.7	43.4	110.3	109.4	263.9	264.1	839.0
11		811.8	106.0	98.0	110.3	134.3	110.4	85.0	26.6	70.2+	108.4	191.5	1359.8	281.2
12		105.3	106.0	498.2	110.3	1070.0	110.3	435.0	37.2	0.0+	103.5	155.9	1184.1	223.1
13	Flow	783.0	110.3	555.7	116.9	185.5	120.4	1091.6	58.3	33.7+	101.3	63.8+	626.4	695.6
14	Recorder	1696.4	112.0	502.6	214.7	146.3	364.5	103.8	57.6+	60.3	101.3	0.0+	1123.2	120.9
15	Operational	167.4	110.3	1151.7	357.5	137.0	254.2	346.6	0.0+	70.5	101.3	0.0+	1008.7	
16	80 11 19	124.5	110.3	1197.5	323.8	127.3	110.3	105.4	0.0+	70.6	101.8	39.0+	294.3	Flow
17		118.9	119.2	1269.5	166.3	119.0	265.3	112.1	0.0+	97.3	89.9	74.3	1433.2	Recorder
18		118.9	414.4	1029.4	20.8	106.0	397.1	1480.5	0.0+	155.8	129.3	70.6	825.1	Removed
19	147.6	118.9	138.3	687.6+	91.0	101.8	131.7	89.7	0.0+	155.8	51.4	74.3	1079.8	81 12 14
20	2870.0	1099.3	329.7	0.0+	153.6	306.1	121.9	69.0	0.0+	352.6	571.9	67.3	702.0	07:00
21	4812.3	3105.7	398.2	0.0+	201.0	1015.6	118.5	153.4	28.6+	143.0	423.5	71.1	1863.4	
22	369.9	1679.1	383.2	0.0+	302.5	2543.5	93.6	225.2	46.7	119.0	326.6	89.7	1362.5	
23	154.5	308.4	258.7	0.0+	149.7	379.8	106.3	422.4	54.1	114.6	79.5	93.6	1058.5	
24	110.3	953.2	118.9	0.0+	307.3	138.6	778.4	93.6	24.5+	132.6	67.1	93.6	1134.2	
25	860.7	1932.0	114.6	92.3+	653.6	127.8	312.3	36.7+	0.0+	760.0	79.5	106.3	1481.6	
26	285.0	4373.9	264.9	237.9	89.7	134.1	109.7	29.7+	0.0+	127.9	196.1	363.6	410.0	
27	2370.0	1228.7	280.6	71.2	93.6	1072.1	106.0	37.7	0.0+	110.4	798.3	939.2	286.1	
28	610.2	284.8	341.3	70.6	972.4	576.2	106.0	95.5	24.9+	97.7	607.3	729.9	340.1	
29	1756.8	492.0	455.6	-	1810.8	231.2	191.9	124.3	37.7	85.8	106.7	95.6	445.5	
30	1779.3	339.7	110.3	-	1628.2	187.4	130.4	165.4	37.7	70.7	663.5	1451.4	2975.2	
31	-	138.4	110.3	-	1532.2	-	99.8	-	37.7	864.8	-	7134.9	-	
Monthly Total	16126.5*	24295.4	5716.9	8474.1*	12526.1	13166.1	8029.3	8161.3*	2894.0*	4776.0	6042.8	21629.2*	23506.3	9077.1*
Average Daily	1452.6	783.7	184.4	366.4	404.1	438.9	259.0	289.1	153.2	166.9	201.4	797.3	783.5	1022.9

Note: Average Daily Flows are calculated only for days when the flow recorder was operational for a full 24 hour period.
* Partial Month
+ Flow recorder breakdown

TABLE 9

RUNOFF COEFFICIENTS

Period of Precipitation	Period of Runoff	Average Storm Duration (hrs)	Total Precipitation (mm)	Total Runoff (m^3)	R
81/01/09, 08:00 to 81/01/09, 09:00	81/01/09, 07:26 to 81/01/09, 12:24	5	3.5	176.3	0.39
81/01/09, 13:00 to 81/01/09, 14:00	81/01/09, 12:24 to 81/01/09, 15:30	3	1.5	90.1	0.46
81/01/17, 14:00 to 81/01/17, 17:00	81/01/17, 14:48 to 81/01/17, 16:24	1.5	1.5	15.0	0.08
81/01/18, 04:00 to 81/01/18, 08:00	81/01/18, 04:24 to 81/01/18, 08:24	4	3.5	98.0	0.22
81/01/18, 09:00 to 81/01/18, 12:00	81/01/18, 08:53 to 81/01/18, 24:00	15	4.5	291.2	0.50
81/01/20, 19:00 to 81/01/21, 03:00	81/01/20, 20:30 to 81/01/21, 08:00	11.5	7.5	372.5	0.38
81/01/27, 22:00 to 81/01/28, 02:00	81/01/27, 22:06 to 81/01/28, 03:00	5	7.5	341.3	0.35
81/01/28, 04:00 to 81/01/28, 05:00	81/01/28, 03:48 to 81/01/28, 06:36	2.75	0.5	14.4	0.22
81/01/28, 07:00 to 81/01/28, 10:00	81/01/28, 07:00 to 81/01/28, 10:48	3.75	1.0	88.6	0.68
81/01/29, 05:00 to 81/01/29, 13:00	81/01/29, 05:00 to 81/01/29, 16:00	11	7.5	393.3	0.40
81/02/12, 07:00 to 81/02/12, 10:00	81/02/12, 08:33 to 81/02/12, 11:12	2.75	1.5	48.9	0.25
81/02/12, 10:00 to 81/02/12, 21:00	81/02/12, 11:17 to 81/02/12, 22:00	10.75	11.5	399.6	0.27
81/02/12, 22:00 to 81/02/12, 23:00	81/02/12, 23:48 to 81/02/13, 00:36	0.75	0.5	7.8	0.12
81/02/13, 01:00 to 81/02/13, 06:00	81/02/13, 04:00 to 81/02/13, 05:34	1.5	2.5	20.1	0.06
81/02/13, 07:00 to 81/02/13, 14:00	81/02/13, 05:41 to 81/02/13, 13:50	8	8.5	296.3	0.27
81/02/13, 22:00 to 81/02/14, 05:00	81/02/13, 20:00 to 81/02/14, 12:36	16.5	11.0	476.9	0.33
81/02/14, 23:00 to 81/02/15, 03:00	81/02/14, 21:27 to 81/02/15, 03:12	5.75	6.0	246.7	0.32
81/02/15, 05:00 to 81/02/15, 17:00	81/02/15, 03:24 to 81/02/15, 23:22	20	20.5	1083.9	0.41
81/02/15, 24:00 to 81/02/16, 08:00	81/02/15, 23:29 to 81/02/16, 13:00	13.5	9.0	789.6	0.68
81/02/16, 12:00 to 81/02/16, 18:00	81/02/16, 13:24 to 81/02/16, 23:00	9.5	5.5	424.4	0.60
81/02/17, 01:00 to 81/02/17, 02:00	81/02/17, 00:46 to 81/01/17, 08:00	7.25	1.0	106.2	0.82
81/02/17, 16:00 to 81/02/18, 02:00	81/02/17, 16:18 to 81/02/18, 18:36	2.25	21.5	1742.1	0.63
81/02/18, 19:00 to 81/02/19, 06:00	81/02/18, 19:00 to 81/02/19, 11:30	16.5	13.5	1087.6	0.62
81/02/26, 05:00 to 81/02/26, 10:00	81/02/26, 05:42 to 81/02/26, 15:00	9.25	3.5	177.3	0.39
81/03/02, 21:00 to 81/03/03, 13:00	81/03/02, 22:48 to 81/03/03, 24:00	25.25	29.0	1616.2	0.43
81/03/15, 08:00 to 81/03/15, 22:00	81/03/15, 07:00 to 81/03/16, 16:00	33	14.5	1012.6	0.54
81/03/21, 24:00 to 81/03/22, 03:00	81/03/21, 23:12 to 81/03/22, 15:12	16	3.5	272.8	0.60
81/03/23, 03:00 to 81/03/22, 08:00	81/03/23, 03:42 to 81/03/23, 08:30	4.75	4.0	64.0	0.12
81/03/24, 22:00 to 81/03/25, 04:00	81/03/24, 22:12 to 81/03/25, 04:00	5.75	15.0	829.4	0.43
81/03/28, 12:00 to 81/03/29, 07:00	81/03/28, 12:00 to 81/03/29, 13:00	25	35.0	1999.9	0.44
81/03/29, 12:00 to 81/03/29, 21:00	81/03/29, 13:42 to 81/03/30, 02:00	12.25	11.0	755.8	0.53
81/03/30, 07:00 to 81/03/31, 08:00	81/03/30, 09:42 to 81/03/31, 19:00	33.25	30.5	3008.7	0.76
81/04/01, 10:00 to 81/04/01, 11:00	81/04/01, 11:57 to 81/04/01, 13:00	1	1.0	26.3	0.20
81/04/02, 08:00 to 81/04/02, 12:00	81/04/02, 07:30 to 81/04/02, 17:00	9.5	2.5	305.7	0.94
81/04/02, 17:00 to 81/04/02, 22:00	81/04/02, 17:50 to 81/04/03, 03:00	9.5	2.5	108.8	0.34
81/04/04, 20:00 to 81/04/05, 06:00	81/04/04, 21:00 to 81/04/05, 23:00	27	16.0	1469.8	0.71
81/04/08, 01:00 to 81/04/08, 13:00	81/04/08, 01:15 to 81/04/08, 24:00	22.75	17.5	899.7	0.40
81/04/10, 20:00 to 81/04/10, 22:00	81/04/10, 21:24 to 81/04/10, 23:54	2.5	1.0	16.3	0.13
81/04/10, 23:00 to 81/04/11, 03:00	81/04/11, 00:54 to 81/04/11, 05:30	5.5	2.0	52.9	0.20
81/04/12, 02:00 to 81/04/12, 12:00	81/04/12, 02:18 to 81/04/12, 24:00	21.75	20.5	1060.2	0.40
81/04/20, 16:00 to 81/04/20, 20:00	81/04/20, 15:45 to 81/04/20, 23:24	7.75	6.0	231.2	0.30
81/04/20, 23:00 to 81/04/21, 12:00	81/04/20, 23:54 to 81/04/21, 12:48	13	9.5	429.4	0.35

TABLE 9 (CONT'D)

Period of Precipitation	Period of Runoff	Average Storm Duration (hrs)	Total Precipitation (mm)	Total Runoff (m^3)	R
81/04/21, 13:00 to 81/04/23, 14:00	81/04/21, 13:30 to 81/04/23, 23:00	57.5	42.0	3495.0	0.64
81/04/27, 06:00 to 81/04/29, 11:00	81/04/27, 09:21 to 81/04/29, 23:00	60.5	26.5	1828.6	0.53
81/04/30, 15:00 to 81/04/30, 16:00	81/04/30, 15:15 to 81/04/30, 21:00	5.75	1.5	75.5	0.39
81/05/01, 18:00 to 81/05/01, 19:00	81/05/01, 18:48 to 81/05/01, 19:18	0.5	0.5	3.8	0.06
81/05/01, 24:00 to 81/05/02, 05:00	81/05/02, 00:30 to 81/05/02, 08:00	7.5	3.5	117.1	0.26
81/05/02, 23:00 to 81/05/02, 24:00	81/05/03, 00:15 to 81/05/03, 02:00	1.75	0.5	11.4	0.18
81/05/03, 08:00 to 81/05/04, 11:00	81/05/03, 08:56 to 81/05/04, 23:00	14	31.5	2071.1	0.51
81/05/06, 04:00 to 81/05/06, 09:00	81/05/06, 05:24 to 81/05/06, 12:00	6.5	2.5	84.6	0.26
81/05/08, 21:00 to 81/05/09, 04:00	81/05/08, 21:24 to 81/05/09, 15:00	17.5	3.5	116.8	0.26
81/05/10, 20:00 to 81/05/10, 22:00	81/05/10, 19:30 to 81/05/10, 22:00	2.5	2.5	61.1	0.19
81/05/13, 11:00 to 81/05/13, 13:00	81/05/13, 10:00 to 81/05/13, 14:30	4.5	1.0	25.8	0.20
81/05/14, 07:00 to 81/05/14, 11:00	81/05/14, 06:19 to 81/05/14, 24:00	17.5	9.5	333.0	0.27
81/05/15, 05:00 to 81/05/15, 08:00	81/05/15, 05:50 to 81/05/15, 15:00	9.25	3.5	181.4	0.40
81/05/17, 18:00 to 81/05/17, 20:00	81/05/17, 18:31 to 81/05/17, 21:00	2.5	1.5	34.0	0.18
81/05/18, 16:00 to 81/05/18, 23:00	81/05/18, 17:00 to 81/05/18, 23:54	7	9.0	312.1	0.27
81/05/21, 09:00 to 81/05/21, 11:00	81/05/21, 10:36 to 81/05/21, 13:00	2.5	1.0	17.2	0.13
81/05/24, 04:00 to 81/05/24, 05:00	81/05/24, 04:54 to 81/05/24, 06:36	1.75	1.0	21.1	0.16
81/05/24, 07:00 to 81/05/24, 08:00	81/05/24, 07:45 to 81/05/24, 10:00	2.25	1.5	47.0	0.24
81/05/24, 19:00 to 81/05/25, 03:00	81/05/24, 20:49 to 81/05/25, 09:00	12.25	19.5	867.5	0.34
81/05/29, 15:00 to 81/05/29, 17:00	81/05/29, 15:39 to 81/05/29, 17:00	1.5	1.5	16.1	0.08
81/05/29, 18:00 to 81/05/29, 21:00	81/05/29, 18:24 to 81/05/29, 22:00	3.5	2.5	59.4	0.21
81/05/29, 22:00 to 81/05/29, 24:00	81/05/29, 22:10 to 81/05/29, 23:54	1.75	1.5	26.5	0.14
81/05/30, 19:00 to 81/05/30, 22:00	81/05/30, 20:18 to 81/05/30, 21:00	0.75	2.0	24.2	0.09
81/06/02, 20:00 to 81/06/02, 24:00	81/06/02, 21:42 to 81/06/03, 00:36	2.75	4.0	71.6	0.14
81/06/03, 04:00 to 81/06/03, 05:00	81/06/03, 04:53 to 82/06/03, 05:40	0.75	1.0	8.2	0.06
81/06/03, 06:00 to 81/06/03, 10:00	81/06/03, 07:31 to 81/06/03, 13:00	5.5	3.0	56.7	0.15
81/06/04, 06:00 to 81/06/04, 08:00	81/06/04, 07:05 to 81/06/04, 11:48	4.75	2.0	35.5	0.14
81/06/08, 12:00 to 81/06/08, 23:00	81/06/08, 13:36 to 81/06/09, 12:00	22.5	14.5	569.1	0.30
81/06/09, 19:00 to 81/06/09, 22:00	81/06/09, 20:12 to 81/06/09, 23:48	3.5	11.5	227.6	0.15
81/06/10, 06:00 to 81/06/10, 09:00	81/06/10, 07:32 to 81/06/10, 13:00	5.5	7.0	331.0	0.37
81/06/10, 14:00 to 81/06/10, 16:00	81/06/10, 16:06 to 81/06/10, 18:00	2	2.5	63.6	0.20
81/06/12, 11:00 to 81/06/12, 13:00	81/06/12, 11:33 to 81/06/12, 16:30	5	8.0	367.9	0.36
81/06/13, 01:00 to 81/06/13, 12:00	81/06/13, 01:00 to 81/06/13, 19:00	18	16.75	1061.1	0.49
81/06/15, 15:00 to 81/06/15, 20:00	81/06/15, 15:38 to 81/06/15, 21:00	5.5	5.5	277.1	0.39
81/06/17, 20:00 to 81/06/17, 23:00	81/06/17, 22:00 to 81/06/18, 02:30	4.5	1.0	23.2	0.18
81/06/18, 04:00 to 81/06/18, 19:00	81/06/18, 05:45 to 81/06/19, 04:00	22.25	25.5	1475.0	0.45
81/06/19, 22:00 to 81/06/19, 24:00	81/06/19, 23:18 to 81/06/20, 04:00	4.75	1.5	44.3	0.23
81/06/21, 09:00 to 81/06/21, 13:00	81/06/21, 10:06 to 81/06/21, 14:00	4	3.5	80.9	0.18
81/06/21, 20:00 to 81/06/21, 21:00	81/06/21, 21:06 to 81/06/21, 22:12	1	1.0	10.5	0.08
81/06/21, 22:00 to 81/06/22, 01:00	81/06/21, 22:46 to 81/06/22, 02:00	3.75	2.0	42.9	0.17
81/06/22, 11:00 to 81/06/22, 13:00	81/06/22, 12:13 to 81/06/22, 15:00	2.75	2.5	119.3	0.37
81/06/22, 24:00 to 81/06/23, 04:00	81/06/23, 00:46 to 81/06/23, 07:00	6.25	6.5	351.6	0.42

TABLE 9 (CONT'D)

Period of Precipitation	Period of Runoff	Average Storm Duration (hrs)	Total Precipitation (mm)	Total Runoff (m^3)	R
81/06/28, 22:00 to 81/06/29, 02:00	81/06/28, 22:33 to 81/06/29, 01:48	3.25	5.0	84.7	0.13
81/06/29, 03:00 to 81/06/29, 05:00	81/06/29, 03:48 to 81/06/29, 06:00	2.25	2.5	57.3	0.18
81/07/05, 06:00 to 81/07/05, 07:00	81/07/05, 06:48 to 81/07/05, 07:30	0.75	0.5	4.6	0.07
81/07/06, 18:00 to 81/07/07, 05:00	81/07/06, 19:07 to 81/07/07, 11:30	16.5	39.5	1666.4	0.33
81/07/07, 18:00 to 81/07/07, 19:00	81/07/07, 18:55 to 81/07/07, 21:00	2	1.0	19.1	0.15
81/07/10, 11:00 to 81/07/10, 14:00	81/07/10, 12:22 to 81/07/10, 14:00	1.5	1.5	12.7	0.07
81/07/13, 12:00 to 81/07/13, 13:00	81/07/13, 13:06 to 81/07/13, 16:00	3	0.5	17.9	0.28
81/08/20, 03:00 to 81/08/20, 09:00	81/08/20, 03:31 to 81/08/20, 18:00	14.5	18.0	787.1	0.34
81/08/25, 04:00 to 81/08/25, 10:00	81/08/25, 04:48 to 81/08/25, 15:30	10.75	15.0	686.9	0.35
81/08/31, 09:00 to 81/08/31, 19:00	81/08/31, 10:10 to 81/08/31, 23:00	13	20.5	833.5	0.31
81/08/31, 24:00 to 81/09/01, 02:00	81/09/01, 00:45 to 81/09/01, 04:00	3.25	2.5	132.7	0.41
81/09/18, 17:00 to 81/09/18, 21:00	81/09/18, 17:18 to 81/09/18, 21:22	4	3.0	69.1	0.18
81/09/20, 14:00 to 81/09/20, 15:00	81/09/20, 14:11 to 81/09/20, 15:02	0.75	0.5	2.5	0.04
81/09/20, 16:00 to 81/09/20, 20:00	81/09/20, 18:12 to 81/09/20, 23:00	4.75	14.5	537.3	0.29
81/09/21, 02:00 to 81/09/21, 05:00	81/09/21, 02:23 to 81/09/21, 11:09	8.5	4.5	224.5	0.39
81/09/21, 16:00 to 81/09/21, 20:00	81/09/21, 16:22 to 81/09/21, 21:56	5.5	4.5	170.1	0.29
81/09/21, 23:00 to 81/09/21, 24:00	81/09/21, 23:06 to 81/09/21, 24:00	1	0.5	1.9	0.03
81/09/22, 02:00 to 81/09/22, 06:00	81/09/22, 02:24 to 81/09/22, 07:22	5	6.0	276.0	0.36
81/09/26, 19:00 to 81/09/26, 22:00	81/09/26, 20:36 to 81/09/26, 23:11	2.5	4.0	135.6	0.26
81/09/26, 24:00 to 81/09/27, 03:00	81/09/27, 00:27 to 81/09/27, 06:24	6	3.5	242.1	0.53
81/09/27, 06:00 to 81/09/27, 09:00	81/09/27, 06:45 to 81/09/27, 11:20	4.5	1.5	40.3	0.21
81/09/27, 11:00 to 81/09/27, 22:00	81/09/27, 11:23 to 81/09/27, 23:30	12	9.5	550.2	0.45
81/09/27, 24:00 to 81/09/28, 08:00	81/09/28, 02:36 to 81/09/28, 11:12	8.5	10.0	503.3	0.39
81/09/28, 12:00 to 81/09/28, 13:00	81/09/28, 12:36 to 81/09/28, 18:00	5.5	0.5	41.8	0.65
81/09/30, 01:00 to 81/09/30, 13:00	81/09/30, 01:07 to 81/09/30, 13:48	12.75	10.5	596.2	0.44
81/10/01, 04:00 to 81/10/02, 20:00	81/10/01, 02:48 to 81/10/02, 17:48	39	33.0	3923.1	0.92
81/10/02, 18:00 to 81/10/02, 20:00	81/10/02, 18:00 to 81/10/02, 22:00	4	1.0	60.3	0.47
81/10/05, 10:00 to 81/10/05, 24:00	81/10/05, 10:09 to 81/10/06, 01:02	14.75	15.0	774.9	0.40
81/10/06, 02:00 to 81/10/06, 05:00	81/10/06, 03:40 to 81/10/06, 06:22	2.75	4.5	188.7	0.32
81/10/06, 15:00 to 81/10/06, 24:00	81/10/06, 16:53 to 81/10/07, 03:00	10	12.0	831.7	0.54
81/10/07, 06:00 to 81/10/07, 10:00	81/10/07, 06:21 to 81/10/07, 15:00	8.75	2.5	354.3	0.91
81/10/07, 18:00 to 81/10/07, 23:00	81/10/07, 19:36 to 81/10/08, 02:30	7	4.0	295.6	0.57
81/10/08, 03:00 to 81/10/08, 06:00	81/10/08, 04:07 to 81/10/08, 13:00	9	1.5	161.6	0.83
81/10/08, 13:00 to 81/10/09, 02:00	81/10/08, 13:18 to 81/10/09, 06:36	17.25	14.0	1355.0	0.75
81/10/09, 05:00 to 81/10/09, 11:00	81/10/09, 06:42 to 81/10/09, 20:00	13.25	6.0	726.4	0.93
81/10/26, 14:00 to 81/10/26, 18:00	81/10/26, 14:49 to 81/10/26, 18:48	4	4.0	181.9	0.35
81/10/26, 22:00 to 81/10/26, 24:00	81/10/26, 22:49 to 81/10/27, 01:00	2.25	1.5	86.8	0.45
81/10/27, 03:00 to 81/10/27, 13:00	81/10/27, 03:47 to 81/10/27, 16:00	12.25	11.0	808.1	0.57
81/10/27, 23:00 to 81/10/28, 06:00	81/10/27, 23:00 to 81/10/28, 07:00	8	7.0	501.7	0.55
81/10/28, 11:00 to 81/10/28, 12:00	81/10/28, 11:10 to 81/10/28, 12:54	1.75	1.5	78.1	0.40
81/10/28, 13:00 to 81/10/28, 14:00	81/10/28, 12:58 to 81/10/28, 16:00	3	1.5	96.5	0.50
81/10/28, 20:00 to 81/10/28, 21:00	81/10/28, 20:00 to 81/10/28, 22:18	2.25	0.5	36.7	0.57

TABLE 9 (CONT'D)

Period of Precipitation	Period of Runoff	Average Storm Duration (hrs)	Total Precipitation (mm)	Total Runoff (m^3)	R
81/10/30, 09:00 to 81/11/01, 05:00	81/10/30, 09:01 to 81/11/01, 23:00	48	38.0	9621.1	0.84
81/11/10, 17:00 to 81/11/10, 18:00	81/11/10, 15:48 to 81/11/10, 17:48	2	0.5	41.5	0.64
81/11/11, 02:00 to 81/11/12, 15:00	81/11/11, 00:31 to 81/11/12, 17:00	40.5	30.5	2442.3	0.62
81/11/13, 06:00 to 81/11/13, 09:00	81/11/13, 07:13 to 81/11/13, 12:00	4.75	3.5	305.2	0.67
81/11/13, 22:00 to 81/11/14, 03:00	81/11/13, 23:31 to 81/11/14, 06:41	6.25	5.0	400.7	0.62
81/11/14, 08:00 to 81/11/14, 14:00	81/11/14, 08:07 to 81/11/14, 15:36	7.5	6.5	551.8	0.66
81/11/15, 12:00 to 81/11/15, 23:00	81/11/15, 13:36 to 81/11/16, 07:48	18.25	10.0	976.7	0.75
81/11/17, 08:00 to 81/11/18, 11:00	81/11/17, 06:30 to 81/11/18, 17:00	10.5	23.5	2116.0	0.70
81/11/19, 13:00 to 81/11/20, 21:00	81/11/19, 13:53 to 81/11/20, 15:00	1	12.5	1257.0	0.78
81/11/20, 22:00 to 81/11/21, 03:00	81/11/20, 21:25 to 81/11/21, 04:12	6.75	8.5	716.7	0.65
81/11/21, 04:00 to 81/11/23, 02:00	81/11/21, 04:20 to 81/11/23, 12:10	53.75	25.0	3036.0	0.94
81/11/24, 02:00 to 81/11/24, 06:00	81/11/24, 01:26 to 81/11/24, 07:00	5.5	9.5	661.3	0.54
81/11/25, 04:00 to 81/11/25, 19:00	81/11/25, 02:30 to 81/11/25, 23:00	20.5	14.5	1428.6	0.76
81/11/29, 04:00 to 81/11/29, 08:00	81/11/29, 04:26 to 81/11/29, 08:54	4.5	3.5	144.5	0.32
81/11/29, 19:00 to 81/11/29, 20:00	81/11/29, 19:34 to 81/11/29, 20:36	1	1.0	31.5	0.24
81/11/30, 08:00 to 81/12/02, 02:00	81/11/30, 08:17 to 81/12/02, 23:00	13.75	68.5	7169.8	0.81
81/12/08, 20:00 to 81/12/08, 22:00	81/12/08, 20:00 to 81/12/08, 24:00	4	2.0	165.4	0.64
81/12/09, 04:00 to 81/12/10, 15:00	81/12/09, 04:00 to 81/12/10, 24:00	44	26.5	2355.3	0.67
81/12/13, 15:00 to 81/12/13, 22:00	81/12/13, 15:00 to 81/12/13, 24:00	9	7.5	529.1	0.54
			Arithmetic Mean		0.40
			5th percentile		0.07
			10th percentile		0.13
			50th percentile		0.38
			90th percentile		0.75
			95th percentile		0.83

Note:
1) Average storm duration is calculated to the nearest 0.25 hours
2) Calculations of R were made for only those days with complete data for runoff and precipitation (i.e. no equipment problems) from the following formula:

$$R = \frac{\text{total runoff } (m^3)}{\text{total precipitation } (m) \times 125\ 500\ m^2 \text{ catchment area}}$$

TABLE 10

DATA SUMMARY

DRY WEATHER STORMWATER QUALITY

Constituent	No. of Values	Values*		
		Maximum	Minimum	Mean
Alkalinity - total ($CaCO_3$)	10	48.1	20.9	33.6
Bacteriological:				
: Fecal Coliform	35	>24000	70	700^+
: Total Coliform	35	>24000	490	9200^+
Carbon - Inorganic (C)	12	13	6	9.2
- Organic (C)	36	88	2	12.1
Colour - TAC	12	21	4	11.6
Hardness: Calcium (Ca)	12	24.1	10.9	18.4
: Magnesium (Mg)	12	2.2	1.1	1.7
Metals: Aluminum - total (Al)	36	1.79	0.04	0.385
: - dissolved (Al)	6	0.10	0.06	0.08
: Arsenic - total (As)	1	<0.005	<0.005	<0.005
: Copper - total (Cu)	36	0.17	0.003	0.04
- dissolved (Cu)	6	0.07	0.02	0.03
: Lead - total (Pb)	36	0.135	<0.001	0.02
- dissolved (Pb)	4	0.035	0.01	0.02
: Manganese - total (Mn)	36	0.21	0.02	0.07
- dissolved (Mn)	6	0.09	0.06	0.08
: Zinc - total (Zn)	36	0.360	0.014	0.086
- dissolved (Zn)	6	0.170	0.080	0.100
Nitrogen: Ammonia (N)	36	0.84	0.008	0.214
: Kjeldahl (N)	36	3	0.17	1.34
: Nitrate/Nitrite (N)	36	2.26	0.2	1.11
: Organic (N)	36	3	0.13	1.2
: Total (N)	36	5	0.53	2.41
Oil and Grease	34	17.5	<1	3.3
Oxygen Demand: BOD_5	12	17	<10	<10
: COD	36	288	<10	38.4
pH	34	7.7	6.0	7.3^+
Pesticides: 2,4-D	6	<0.001	<0.001	<0.001
: Captan	6	<0.01	<0.01	<0.01
: Diazinon	6	<0.001	<0.001	<0.001
: Dicamba	6	<0.0002	<0.0002	<0.0002
: Mecoprop	6	<0.001	<0.001	<0.001
: Methoxychlor	6	<0.0008	<0.0008	<0.0008
Phenol	12	0.208	0.005	0.037
Phosphorus - total (P)	66	0.315	0.006	0.067
Polychlorinated Biphenyls:				
: Arochlor - 1242	6	<0.002	<0.002	<0.002
- 1254	6	<0.002	<0.002	<0.002
- 1260	6	<0.002	<0.002	<0.002
Specific Conductance	34	190	45	103

TABLE 10 (CONT'D)

Constituent	No. of Values	Values*		
		Maximum	Minimum	Mean
Suspended Solids - total	30	46	1	13.6
- fixed	30	31	<1	7.7
Tannin and Lignin	12	2.7	0.3	0.95

+ 50th Percentile value
* All values are in mg/L except:

(1) Coliform as MPN/100 mL
(2) Colour as colour units
(3) pH as relative units
(4) Specific Conductance as µmhos/cm

TABLE 11

DATA SUMMARY

WET WEATHER STORMWATER QUALITY

Constituent	No. of Values	Values*			Ratio Max : Min
		Maximum	Minimum	Mean	
Alkalinity - total ($CaCO_3$)	106	37.4	5.5	15	6.8:1
Bacteriological:					
: Fecal Coliform	255	>24000	<20	2400^+	-
: Total Coliform	255	>24000	80	9200^+	≈300:1
Carbon - Inorganic (C)	107	10	<1	3.56	≈10:1
- Organic (C)	257	230	2	10.1	115:1
Colour - TAC	106	64	2	14	32:1
Hardness: Calcium (Ca)	107	19.3	2	2.4	9.65:1
: Magnesium (Mg)	106	1.62	0.04	0.57	40.5:1
Metals: Aluminum - total (Al)	257	14.9	<0.02	0.43	≈745:1
- dissolved (Al)	6	0.04	<0.02	0.03	≈2:1
: Arsenic - total (As)	9	0.06	<0.05	<0.05	≈1.2:1
: Cadmium - total (Cd)	9	0.01	<0.01	<0.01	≈1:1
: Chromium - total (Cr)	9	0.03	<0.01	<0.01	≈3:1
: Copper - total (Cu)	256	0.560	0.004	0.037	140:1
- dissolved (Cu)	23	0.020	<0.001	0.007	≈20:1
: Iron - total (Fe)	81	15.4	0.03	0.918	513.3:1
- dissolved (Fe)	24	0.120	<0.001	0.022	≈120:1
: Lead - total (Pb)	254	1.71	0.003	0.071	570:1
- dissolved (Pb)	24	0.020	0.004	0.009	5:1
: Manganese - total (Mn)	257	0.55	<0.01	0.04	≈55:1
- dissolved (Mn)	6	0.02	0.01	0.01	≈2:1
: Mercury - total (Hg)	9	0.0002	<0.00005	0.00009	≈4:1
: Molybdenum - total (Mo)	9	0.01	<0.01	<0.01	≈1:1
: Nickel - total (Ni)	9	<0.05	<0.05	<0.05	≈1:1
: Zinc - total (Zn)	255	1.57	0.02	0.12	78.5:1
- dissolved (Zn)	24	0.21	0.05	0.08	4.2:1
Nitrogen: Ammonia (N)	256	0.735	<0.005	0.172	≈147:1
: Kjeldahl (N)	255	5	0.11	1.07	45.5:1
: Nitrate/Nitrite (N)	256	1.94	0.11	0.54	17.6:1
: Organic (N)	255	5	0.04	0.96	125:1
: Total (N)	255	6	0.34	1.61	17.6:1
Oil and Grease	246	27.6	<1	3	≈27.6:1
Oxygen Demand: BOD_5	107	23	<10	<10	2.3:1
: COD	257	739	<10	33.2	73.9:1
pH	256	7.5	5.6	6.7^+	-
Phenol	107	0.12	<0.002	0.013	60:1
Phosphorus - total (P)	519	1.18	0.008	0.089	147.5:1
Polychlorinated Biphenyls:					
: Arochlor - 1242	19	<0.0004	<0.0004	<0.0004	-
- 1254	19	<0.0004	<0.0004	<0.0004	-
- 1260	19	<0.0004	<0.0004	<0.0004	-

TABLE 11 (CONT'D)

Constituent	No. of Values	Values*			Ratio Max Min
		Maximum	Minimum	Mean	
Specific Conductance	256	283	2	52	141.5:1
Suspended Solids - total	231	342	2	19.8	171:1
- fixed	231	252	<1	11	≈252:1
Tannin and Lignin	106	3.8	0.2	0.88	10:1

+ 50th Percentile value

* All values are in mg/L except:

(1) Coliform as MPN/100 mL
(2) Colour as colour units
(3) pH as relative units
(4) Specific Conductance as mg/L

TABLE 12

DRY WEATHER STORMWATER LOADINGS

Sampling Duration	Total Flow (m^3)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
80/12/17, 14:00 to 80/12/17, 14:15	1.2	0.012	0.024	0.011	0.00025	0.00003	0.00010	0.00008	0.0060	0.00009
80/12/17, 14:15 to 80/12/17, 14:30	1.2	0.011	<0.012	0.006	0.00023	0.00002	0.00011	0.00005	0.0048	0.00007
80/12/17, 14:30 to 80/12/17, 14:45	1.2	0.007	<0.012	0.005	0.00012	0.00002	0.00002	0.00008	0.0048	0.00008
80/12/17, 14:45 to 80/12/17, 15:00	1.2	0.012	0.019	0.004	0.00013	0.00001	0.00006	0.00007	0.0048	0.00015
80/12/17, 15:00 to 80/12/17, 15:15	1.2	0.008	<0.012	0.005	0.00005	0.00001	0.00005	0.00008	0.0036	0.00006
80/12/17, 15:15 to 80/12/17, 15:30	1.2	0.013	0.014	0.006	0.00026	0.00002	0.00020	0.00017	0.0048	0.00007
81/05/13, 13:00 to 81/05/13, 13:15	1.5	0.039	0.128	0.051	0.00100	0.00002	0.00011	0.00024	0.0060	0.00025
81/05/13, 13:15 to 81/05/13, 13:30	1.5	0.013	0.077	0.033	0.00048	0.00006	0.00003	0.00012	0.0045	0.00016
81/05/13, 13:30 to 81/05/13, 13:45	1.5	0.105	0.045	0.021	0.00035	0.00002	0.00003	0.00008	0.0029	0.00018
81/05/13, 13:45 to 81/05/13, 14:00	1.4	0.015	0.044	0.020	0.00041	0.00003	0.00003	0.00012	0.0034	0.00015
81/05/13, 14:00 to 81/05/13, 14:15	1.4	0.009	0.038	0.020	0.00030	0.00002	0.00003	0.00009	0.0030	0.00011
81/05/13, 14:15 to 81/05/13, 14:30	1.4	0.006	0.032	0.011	0.00030	0.00002	0.00002	0.00020	0.0023	0.00007
81/08/16, 16:00 to 81/08/16, 16:15	0.74	0.003	<0.007	0.002	0.00007	0.00002	0.00003	0.00003	0.0022	0.00003
81/08/16, 16:15 to 81/08/16, 16:30	0.74	0.001	0.031	0.004	0.00013	0.00002	0.00003	0.00007	0.0011	0.00003
81/08/16, 16:30 to 81/08/16, 16:45	0.74	0.010	0.019	0.005	0.00019	0.00003	0.00004	0.00027	0.0022	0.00006
81/08/16, 16:45 to 81/08/16, 17:00	0.74	0.005	0.019	0.003	0.00013	0.00002	0.00002	0.00012	0.0014	0.00005
81/08/16, 17:00 to 81/08/16, 17:15	0.74	0.014	0.019	0.004	0.00012	0.00010	0.00004	0.00002	0.0022	0.00006
81/08/16, 17:15 to 81/08/16, 17:30	0.74	0.004	0.019	0.005	0.00011	0.00002	0.00008	0.00009	0.0017	0.00005
81/08/16, 17:30 to 81/08/16, 17:45	0.74	0.003	0.009	0.001	0.00006	0.00001	0.00001	0.00003	0.0015	0.00003
81/08/16, 17:45 to 81/08/16, 18:00	0.74	0.004	0.016	0.005	0.00006	0.00001	0.00003	0.00001	0.0022	0.00005
81/08/16, 18:00 to 81/08/16, 18:15	0.74	0.003	0.009	0.003	0.00008	0.00002	0.00003	0.00002	0.0014	0.00003
81/08/16, 18:15 to 81/08/16, 18:30	0.74	0.002	0.009	0.002	0.00006	0.00001	0.00001	0.00002	0.0012	0.00003
81/08/16, 18:30 to 81/08/16, 18:45	0.74	0.003	0.009	0.002	0.00007	0.00001	0.00001	0.00001	0.0014	0.00003
81/08/16, 18:45 to 81/08/16, 19:00	0.74	0.001	0.009	0.002	0.00007	0.00001	0.00001	0.00015	0.0013	0.00003
81/08/26, 10:30 to 81/08/26, 10:45	1.33	0.003	<0.013	0.004	0.00007	0.00001	0.00000	0.00003	0.0007	0.00002
81/08/26, 10:45 to 81/08/26, 11:00	1.33	0.011	<0.013	0.004	0.00023	0.00002	0.00001	0.00003	0.0009	0.00004
81/08/26, 11:00 to 81/08/26, 11:15	1.33	0.003	<0.013	0.004	0.00008	0.00001	0.00001	0.00003	0.0007	0.00002
81/08/26, 11:15 to 81/08/26, 11:30	1.33	0.001	<0.013	0.004	0.00005	0.00000	0.00000	0.00002	0.0007	0.00002
81/08/26, 11:30 to 81/08/26, 11:45	1.33	0.001	<0.013	0.004	0.00008	0.00000	0.00001	0.00003	0.0007	0.00002
81/08/26, 11:45 to 81/08/26, 12:00	1.33	0.001	<0.013	0.004	0.00009	0.00001	0.00000	0.00003	0.0007	0.00002

TABLE 12 CONT'D

Sampling Duration	Total Flow (m^3)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/11/10, 15:40 to 81/11/10, 15:55	3.0	0.138	0.364	0.264	0.00030	0.00003	0.00021	0.00051	0.0120	0.00050
81/11/10, 15:55 to 81/11/10, 16:10	3.6	0.166	0.439	0.133	0.00644	0.00004	0.00014	0.00043	0.0108	0.00090
81/11/10, 16:10 to 81/11/10, 16:25	4.8	0.215	0.523	0.158	0.00778	0.00024	0.00024	0.00077	0.0144	0.00123
81/11/10, 16:25 to 81/11/10, 16:40	6.3	0.227	0.630	0.164	0.00033	0.00002	0.00019	0.00063	0.0139	0.00154
81/11/10, 16:40 to 81/11/10, 16:55	8.2	0.353	0.716	0.197	0.01033	0.00090	0.00033	0.00107	0.0246	0.00258
81/11/10, 16:55 to 81/11/10, 17:10	7.7	0.293	0.670	0.177	0.00932	0.00089	0.00015	0.00077	0.0154	0.00225
81/11/10, 17:10 to 81/11/10, 17:48	10.0		STORM TERMINATION							
FLOW-WEIGHTED MEAN CONCENTRATION (mg/L)		25.9	67.3	20.3	0.61	0.04	0.04	0.096	2.60	0.17
MEAN 15 MINUTE LOAD (ALL STORMS)		0.048	0.125	0.037	0.00112	0.00007	0.00007	0.00013	0.0048	0.00031
MEAN DAILY LOAD (ALL STORMS)		4.59	12.0	3.60	0.108	0.007	0.007	0.017	0.46	0.03

MEAN FLOW: 1.84 m^3/15 minutes or 176.96 m^3/d.

TABLE 13

WET WEATHER STORMWATER LOADINGS

Sampling Duration	Total Flow (m^3)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/01/20, 20:00 to 81/01/20, 21:00	13.9	BEGINNING OF STORM								
81/01/20, 21:00 to 81/01/20, 21:15	8.6	0.232	0.370	0.095	0.005	0.0010	0.0002	0.0003	0.0090	0.0010
81/01/20, 21:15 to 81/01/20, 21:30	7.7	0.136	0.293	0.069	0.003	0.0067	0.0001	0.0005	0.0170	0.0008
81/01/20, 21:30 to 81/01/20, 21:45	7.0	0.105	0.210	0.042	0.003	0.0005	0.0001	0.0004	0.0040	0.0005
81/01/20, 21:45 to 81/01/20, 22:00	6.6	0.086	0.165	0.040	0.002	0.0004	0.0001	0.0003	0.0040	0.0004
81/01/20, 22:00 to 81/01/20, 22:15	8.1	0.146	0.243	0.057	0.003	0.0005	0.0007	0.0004	0.0120	0.0007
81/01/20, 22:15 to 81/01/20, 22:30	17.4	0.696	0.592	0.209	0.013	0.0022	0.0003	0.0016	0.0300	0.0021
81/01/20, 22:30 to 81/01/20, 22:45	23.3	NO DATA								
81/01/20, 22:45 to 81/01/20, 23:00	28.0	NO DATA								
81/01/20, 23:00 to 81/01/21, 01:30	161.8	NO DATA								
81/01/21, 01:30 to 81/01/21, 03:00	15.7	0.110	0.577	0.141	0.008	0.0013	0.0009	0.0028	0.0470	0.0025
81/01/21, 03:00 to 81/01/21, 04:30	32.6	0.489	0.704	0.196	0.007	0.0007	0.0091	0.0052	0.0326	0.0027
81/01/21, 04:30 to 81/01/21, 06:00	30.4	0.243	0.760	0.152	0.008	0.0008	0.0094	0.0043	0.0304	0.0023
81/01/21, 06:00 to 81/01/21, 07:30	10.5	0.152	0.227	0.042	0.003	0.0001	0.0059	0.0012	0.0105	0.0011
81/01/28, 07:00 to 81/01/28, 07:15	2.6	0.120	0.131	0.049	0.002	0.0002	0.0001	0.0004	0.0080	0.0010
81/01/28, 07:15 to 81/01/28, 07:45	13.4	0.710	0.619	0.161	0.008	0.0013	0.0003	0.0015	0.0270	0.0050
81/01/28, 07:45 to 81/01/28, 08:05	14.8	0.503	0.622	0.163	0.005	0.0008	0.0002	0.0010	0.0300	0.0040
81/01/28, 08:05 to 81/01/28, 08:30	16.0	0.544	0.528	0.160	0.017	0.0032	0.0005	0.0019	0.0160	0.0040
81/01/28, 08:30 to 81/01/28, 11:00	41.7	STORM TERMINATION								
81/01/29, 05:00 to 81/01/29, 09:00	183.4	BEGINNING OF STORM								
81/01/29, 09:00 to 81/01/29, 09:15	12.4	0.273	0.310	0.062	0.005	0.0006	0.0006	0.0015	0.0248	0.0027
81/01/29, 09:15 to 81/01/29, 09:30	13.8	0.719	0.345	0.097	0.009	0.0008	0.0021	0.0022	-	0.0035
81/01/29, 09:30 to 81/01/29, 09:45	15.1	0.664	0.433	0.060	0.006	0.0009	0.0009	0.0017	0.0134	0.0017
81/01/29, 09:45 to 81/01/29, 10:00	13.1	0.328	0.328	0.052	0.005	0.0005	0.0013	0.0016	0.0138	0.0009
81/01/29, 10:00 to 81/01/29, 10:15	9.7	0.087	0.281	0.039	0.004	0.0005	0.0004	0.0012	0.0088	0.0009
81/01/29, 10:15 to 81/01/29, 10:30	9.3	0.316	0.270	0.047	0.005	0.0005	0.0020	0.0016	0.0186	0.0019
81/01/29, 10:30 to 81/01/29, 15:00	129.5	STORM TERMINATION								

TABLE 13 (Continued)

Sampling Duration	Total Flow (m^3)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/02/12, 08:00 to 81/02/12, 08:15	1.1	0.133	0.057	0.013	0.001	0.0001	0.0000	0.0002	0.0033	0.0005
81/02/12, 08:15 to 81/02/12, 08:30	1.1	0.129	0.052	0.013	0.001	0.0002	0.0000	0.0002	0.0033	0.0005
81/02/12, 08:30 to 81/02/12, 09:00	7.6	0.306	0.327	0.129	0.002	0.0007	0.0001	0.0015	0.0228	0.0616
81/02/12, 09:00 to 81/02/12, 09:30	10.3	0.443	0.374	0.140	0.005	0.0008	0.0005	0.0021	0.0324	0.0016
81/02/12, 09:30 to 81/02/12, 11:00	29.1	STORM TERMINATION								
81/02/12, 11:00 to 81/02/12, 16:00	236.7	NEW STORM - NOT SAMPLED								
81/02/12, 16:00 to 81/02/12, 17:75	34.7	SECOND PEAK - NOT SAMPLED								
81/02/16, 13:00 to 81/02/16, 15:30	189.2	BEGINNING OF STORM								
81/02/16, 15:30 to 81/02/16, 15:45	22.1	0.237	<0.221	0.083	0.004	0.0006	0.0001	0.0013	0.0150	0.0007
81/02/16, 15:45 to 81/02/16, 16:00	19.7	0.335	0.335	0.099	0.009	0.0007	0.0002	0.0024	0.0193	0.0009
81/02/16, 16:00 to 81/02/16, 16:15	17.7	0.106	<0.177	0.089	0.002	0.0003	0.0001	0.0014	0.0150	0.0006
81/02/16, 16:15 to 81/02/16, 16:30	13.8	0.069	<0.138	0.041	0.002	0.0002	0.0001	0.0011	0.0135	0.0004
81/02/16, 16:30 to 81/02/16, 16:45	14.3	0.086	<0.143	0.043	0.002	0.0002	0.0001	0.0010	0.0296	0.0004
81/02/16, 16:45 to 81/02/16, 17:00	14.7	0.059	<0.147	0.059	0.002	0.0002	0.0001	0.0007	0.0441	0.0004
81/02/16, 17:00 to 81/01/16, 17:15	10.1									
81/02/16, 17:00 to 81/01/16, 21:00	113.3	STORM TERMINATION								
81/02/17, 15:30 to 81/02/17, 15:45	1.2	0.002	<0.012	0.006	0.000	0.0000	0.0000	0.0000	0.0027	0.0000
81/02/17, 15:45 to 81/02/17, 16:00	1.2	0.004	<0.012	0.006	0.000	0.0000	0.0000	0.0001	0.0025	0.0000
81/02/17, 16:00 to 81/02/17, 16:15	1.2	0.008	0.020	0.007	0.000	0.0000	0.0000	0.0001	0.0022	0.0000
81/02/17, 16:15 to 81/02/17, 16:30	2.7	0.041	0.046	0.019	0.001	0.0001	0.0000	0.0001	0.0040	0.0002
81/02/17, 16:30 to 81/02/17, 16:45	7.2	0.065	0.122	0.050	0.002	0.0003	0.0004	0.0004	0.0096	0.0004
81/02/17, 16:45 to 81/02/17, 17:00	7.5	0.090	0.090	0.045	0.001	0.0002	0.0002	0.0004	0.0098	0.0004
81/02/17, 17:00 to 81/02/18, 11:35	1655.3	STORM TERMINATION								
81/02/18, 19:00 to 81/02/18, 19:15	14.0	0.154	0.238	0.070	0.004	0.0006	0.0002	0.0006	0.0344	0.0008
81/02/18, 19:15 to 81/02/18, 19:30	10.1	0.111	0.121	0.030	0.003	0.0012	0.0007	0.0009	0.0246	0.0006
81/02/18, 19:30 to 81/02/18, 19:45	10.1	0.101	0.121	0.030	0.002	0.0003	0.0003	0.0004	0.0135	0.0005
81/02/18, 19:45 to 81/02/18, 20:00	12.8	0.166	0.154	0.051	0.004	0.0005	0.0004	0.0004	0.0142	0.0006
81/02/18, 20:00 to 81/02/18, 20:15	18.6	0.136	<0.136	0.037	0.004	0.0005	0.0004	0.0007	0.0201	0.0007
81/02/18, 20:15 to 81/02/18, 20:30	23.8	0.238	<0.238	0.071	0.003	0.0005	0.0002	0.0010	0.0205	0.0008
81/02/18, 20:30 to 81/02/19, 11:30	1004.1	STORM TERMINATION								

TABLE 13 (Continued)

Sampling Duration	Total Flow (m^3)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/02/26, 06:00 to 81/02/26, 08:00	62.7	BEGINNING OF STORM								
81/02/26, 08:00 to 81/02/26, 08:15	6.9	0.110	0.133	0.043	0.002	0.0002	0.0004	0.0007	0.0414	0.0004
81/02/26, 08:15 to 81/02/26, 08:30	9.3	0.112	0.149	0.065	0.001	0.0002	0.0002	0.0001	0.0372	0.0005
81/02/26, 08:30 to 81/02/26, 08:45	5.4	0.092	0.065	0.033	0.000	0.0001	0.0002	0.0004	0.0162	0.0009
81/02/26, 08:45 to 81/02/26, 09:00	9.6	0.144	<0.096	0.096	0.001	0.0003	0.0002	0.0007	0.0191	0.0005
81/02/26, 09:00 to 81/02/25, 09:15	23.2	0.557	0.371	0.136	0.005	0.0015	0.0004	0.0016	0.0220	0.0015
81/02/26, 09:15 to 81/02/26, 09:30	15.0	0.150	0.136	0.090	0.002	0.0006	0.0003	0.0011	0.0117	0.0007
81/02/26, 09:30 to 81/02/26, 12:00	27.7	STORM TERMINATION								
81/03/02, 23:00 to 81/03/03, 10:00	799.4	BEGINNING OF STORM								
81/03/03, 10:00 to 81/03/03, 11:30	264.7	12.706	8.470	2.113	0.056	0.0132	0.0132	0.0291	0.7940	0.0442
81/03/03, 11:30 to 81/03/03, 13:00	311.1	6.222	7.466	1.867	0.040	0.0079	0.0311	0.0137	0.3110	0.0243
81/03/03, 13:00 to 81/03/03, 14:50	39.9	4.135	1.798	0.450	0.025	0.0022	0.0054	0.0054	0.0900	0.0110
81/03/03, 14:50 to 81/03/03, 16:00	42.9	3.389	0.858	0.215	0.025	0.0011	0.0159	0.0034	0.0858	0.0099
81/03/24, 22:00 to 81/03/24, 22:45	38.5	BEGINNING OF STORM								
81/03/24, 22:45 to 81/03/24, 23:00	26.1	0.940	0.940	0.287	0.012	0.0026	0.0010	0.0026	0.0522	0.0035
81/03/24, 23:00 to 81/03/24, 23:15	29.9	0.568	0.957	0.209	0.014	0.0027	0.0012	0.0030	0.0299	0.0023
81/03/24, 23:15 to 81/03/24, 23:30	32.7	0.523	0.654	0.154	0.012	0.0014	0.0016	0.0049	0.0738	0.0039
81/03/24, 23:30 to 81/03/24, 23:45	42.3	1.734	1.210	0.169	0.019	0.0034	0.0013	0.0042	0.1066	0.0053
81/03/24, 23:45 to 81/03/24, 24:00	44.4	0.400	<0.444	0.311	0.007	0.0013	0.0008	0.0036	0.0431	0.0025
81/03/24, 24:00 to 81/03/25, 00:15	40.3	0.226	0.498	0.163	0.006	0.0007	0.0020	0.0053	0.0326	0.0018
81/03/25, 00:15 to 81/03/25, 05:00	520.3	STORM TERMINATION								
81/04/08, 01:00 to 81/04/08, 08:00	332.0	BEGINNING OF STORM								
81/04/08, 08:00 to 81/04/08, 08:15	10.6	0.085	0.127	0.032	0.002	0.0002	0.0001	0.0011	0.0225	0.0004
81/04/08, 08:15 to 81/04/08, 08:30	10.8	0.065	0.184	0.032	0.001	0.0002	0.0002	0.0013	0.0098	0.0004
81/04/08, 08:30 to 81/04/08, 08:45	12.8	0.102	0.154	0.038	0.001	0.0003	0.0002	0.0010	0.0109	0.0005
81/04/08, 08:45 to 81/04/08, 09:00	14.3	0.104	0.252	0.030	0.003	0.0003	0.0003	0.0012	0.0108	0.0006
81/04/08, 09:00 to 81/04/08, 09:15	16.4	0.164	0.197	0.066	0.002	0.0003	0.0005	0.0016	0.0130	0.0008
81/04/08, 09:15 to 81/04/08, 09:30	21.6	0.324	0.367	0.036	0.007	0.0010	-	0.0017	0.0177	0.0011
81/04/08, 09:30 to 81/04/08, 13:00	392.0	STORM TERMINATION								

TABLE 13 (Continued)

Sampling Duration	Total Flow (m³)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/04/21, 02:00 to 81/04/21, 12:00	406.4									
81/04/21, 02:00 to 81/04/21, 08:00	277.2	BEGINNING OF STORM								
81/04/21, 08:00 to 81/04/21, 08:15	27.2	0.435	0.354	0.136	0.004	0.0008	0.0002	0.0030	0.0348	0.0018
81/04/21, 08:15 to 81/04/21, 08:30	11.5	0.092	<0.115	0.058	0.001	0.0003	0.0001	0.0013	0.0125	0.0006
81/04/21, 08:30 to 81/04/21, 08:45	12.0	0.072	0.164	0.060	0.001	0.0003	0.0002	0.0016	0.0143	0.0009
81/04/21, 08:45 to 81/04/21, 09:00	12.5	0.416	<0.126	0.063	0.006	0.0011	0.0003	0.0016	0.0165	0.0013
81/04/21, 09:00 to 81/04/21, 09:15	10.0	0.130	0.130	0.050	0.003	0.0001	0.0002	0.0012	0.0127	0.0007
81/04/21, 09:15 to 81/04/21, 09:30	6.7	0.040	<0.067	0.034	0.001	0.0002	0.0002	0.0009	0.0083	0.0003
81/04/21, 09:30 to 81/04/21, 12:00	49.2									
81/04/21, 12:00 to 81/04/21, 17:45	104.0	PERIOD NOT SAMPLED								
81/04/21, 17:00 to 81/04/21, 17:45	28.7									
81/04/21, 17:45 to 81/04/21, 19:45	69.5	0.973	1.571	0.487	0.007	0.0012	0.0012	0.0063	0.2085	0.0081
81/04/21, 19:45 to 81/04/21, 21:45	82.7	1.406	<0.327	0.496	0.009	0.0013	0.0009	0.0083	0.2481	0.0073
81/04/21, 21:45 to 81/04/21, 23:45	311.9	6.362	4.055	1.560	0.059	0.0106	0.0053	0.0343	0.9357	0.0340
81/04/21, 23:45 to 81/04/22, 01:45	341.6	8.198	<3.416	1.708	0.055	0.0089	0.0033	0.0307	0.3416	0.0325
81/04/22, 01:45 to 81/04/22, 03:45	385.0	3.850	<3.850	0.770	0.039	0.0096	0.0039	0.0308	0.3850	0.0520
81/04/22, 03:45 to 81/04/22, 05:45	433.5	23.309	<4.335	1.301	0.056	0.0131	0.0052	0.0347	0.4335	0.0538
81/04/22, 05:45 to 81/04/22, 09:45	594.1	PERIOD NOT SAMPLED								
81/04/22, 09:45 to 81/04/22, 10:30	63.2	0.342	0.853	0.315	0.012	0.0015	0.0010	0.0111	0.1542	0.0037
81/04/22, 10:30 to 81/04/22, 12:45	108.3	0.650	1.462	0.542	0.023	0.0024	0.0042	0.0076	0.1971	0.0073
81/04/22, 12:45 to 81/04/22, 14:15	133.1	0.799	1.797	0.799	0.017	0.0021	0.0030	0.0106	0.3101	0.0113
81/04/22, 14:15 to 81/04/22, 16:00	172.7	1.382	2.331	0.864	0.022	0.0029	0.0104	0.0123	0.5008	0.0342
81/04/22, 16:00 to 81/04/22, 17:15	57.8	0.636	0.780	0.289	0.012	0.0011	0.0035	0.0052	0.1405	0.0057
81/04/22, 17:15 to 81/04/22, 19:00	64.3	0.385	<0.643	0.386	0.007	0.0008	0.0045	0.0058	0.1608	0.0079
81/04/22, 19:00 to 81/04/22, 24:00	213.3	PERIOD NOT SAMPLED								
81/04/21 01:00 to 81/04/22, 24:00	3550.8									
81/04/29, 09:00 to 81/04/29, 10:00	9.8	BEGINNING OF STORM								
81/04/29, 10:00 to 81/04/29, 10:15	6.9	0.090	0.173	0.035	0.001	0.0002	0.0001	0.0009	0.0138	0.0008
81/04/29, 10:15 to 81/04/29, 10:30	6.3	0.076	0.158	0.038	0.001	0.0002	0.0003	0.0006	0.0095	0.0007
81/04/29, 10:30 to 81/04/29, 10:45	4.1	0.053	0.082	0.029	0.000	0.0001	0.0001	0.0002	0.0068	0.0003
81/04/29, 10:45 to 81/04/29, 11:00	3.8	0.053	0.110	0.027	0.001	0.0001	0.0002	0.0002	0.0076	0.0005
81/04/29, 11:00 to 81/04/29, 11:15	6.2	0.056	0.155	0.037	0.001	0.0002	0.0001	0.0004	0.0091	0.0004
81/04/29, 11:15 to 81/04/29, 11:30	6.4	0.102	0.160	0.045	0.001	0.0003	0.0002	0.0004	0.0111	0.0006
81/04/29, 09:00 to 81/04/29, 13:00	65.3									

TABLE 13 (Continued)

Sampling Duration	Total Flow (m^3)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/05/18, 17:00 to 81/05/18, 18:55	27.3	PRE-STORM RAIN								
81/05/18, 18:55 to 81/05/18, 20:55	35.3	1.450	1.160	0.313	0.015	0.0030	0.0200	0.0060	0.0706	0.0100
81/05/18, 20:55 to 81/05/18, 22:55	239.0	9.320	5.980	2.390	0.129	0.0160	0.0190	0.0600	0.4780	0.0440
81/05/18, 22:55 to 81/05/19, 00:55	16.3	0.336	0.210	0.084	0.002	0.0004	0.0002	0.0030	0.0340	0.0030
81/05/19, 00:55 to 81/05/19, 02:55	12.6	0.302	0.151	0.050	0.003	0.0003	0.0014	0.0020	0.0210	0.0030
81/05/19, 02:55 to 81/05/19, 04:55	11.3	0.260	0.136	0.045	0.002	0.0002	0.0011	0.0020	0.0230	0.0020
81/05/19, 04:55 to 81/05/19, 06:55	10.7	0.171	0.128	0.043	0.002	0.0002	0.0004	0.0020	0.0110	0.0010
81/05/24, 20:45 to 81/05/24, 21:15	72.5	PRE-STORM SAMPLING								
81/05/24, 21:15 to 81/05/24, 23:45	553.0	7.189	9.401	1.659	0.608	0.0100	0.0156	0.0654	0.0940	0.0371
81/05/24, 23:45 to 81/05/25, 01:15	59.9	4.133	1.557	0.479	0.079	0.0060	0.0006	0.0102	0.0600	0.0096
81/05/25, 01:15 to 81/05/25, 03:15	131.1	1.967	2.753	0.393	0.030	0.0034	0.0039	0.0524	0.1652	0.0079
81/05/25, 03:15 to 81/05/25, 05:15	29.3	0.234	0.498	0.059	0.003	0.0004	0.0006	0.0021	0.0378	0.0013
81/05/25, 05:15 to 81/05/25, 07:15	16.6	0.249	0.282	0.050	0.002	0.0004	0.0005	0.0027	0.0234	0.0008
81/05/25, 07:15 to 81/05/25, 09:15	13.7	0.206	0.233	0.055	0.002	0.0002	0.0004	0.0015	0.0278	0.0007
81/06/08, 13:00 to 81/06/08, 13:15	0.7	0.052	0.067	0.020	0.001	0.0001	0.0000	0.0001	0.0021	0.0002
81/06/08, 13:15 to 81/06/08, 13:30	0.7	0.046	0.057	0.022	0.001	0.0001	0.0000	0.0001	0.0014	0.0002
81/06/08, 13:30 to 81/06/08, 13:45	2.3	0.076	0.108	0.046	0.002	0.0002	0.0000	0.0002	0.0023	0.0005
81/06/08, 13:45 to 81/06/08, 14:00	9.7	1.174	0.737	0.330	0.022	0.0011	0.0004	0.0009	0.0194	0.0031
81/06/08, 14:00 to 81/06/08, 14:15	11.7	0.527	0.345	0.105	0.009	0.0023	0.0001	0.0008	0.0077	0.0015
81/06/08, 14:15 to 81/06/08, 14:30	33.3	0.366	0.566	0.233	0.004	0.0015	0.0002	0.0010	0.0173	0.0023
81/06/08, 14:30 to 81/06/08, 20:00	301.1	END OF STORM								
81/06/08, 13:00 to 81/06/08, 20:00	359.6	TOTAL FLOW FOR STORM								
81/06/18, 05:36 to 81/06/18, 07:00	120.3	BEGINNING OF STORM								
81/06/18, 07:00 to 81/06/18, 07:15	15.2	0.091	0.319	0.106	0.002	0.0003	0.0005	0.0020	0.0210	0.0007
81/06/18, 07:15 to 81/06/18, 07:30	17.0	0.170	0.272	0.102	0.003	0.0005	0.0002	0.0019	0.0170	0.0009
81/06/18, 07:30 to 81/06/18, 07:45	14.4	0.086	0.243	0.072	0.002	0.0003	0.0001	0.0007	0.0099	0.0006
81/06/18, 07:45 to 81/06/18, 08:00	23.4	0.187	0.594	0.140	0.004	0.0006	0.0002	0.0016	0.0124	0.0011
81/06/18, 08:00 to 81/06/18, 08:15	22.7	0.159	<0.227	0.091	0.003	0.0005	0.0001	0.0016	0.0077	0.0010
81/06/18, 08:15 to 81/06/18, 08:30	21.2	0.127	<0.212	0.085	0.003	0.0004	0.0001	0.0015	0.0093	0.0009
81/06/18, 08:30 to 81/06/18, 24:00	1213.4	END OF STORM								
81/06/18, 05:36 to 81/06/18, 24:00	1453.6	TOTAL STORM FLOW								

TABLE 13 (Continued)

Sampling Duration	Total Flow (m^3)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/06/30, 07:30 to 81/06/30, 07:45	0.5	0.002	0.000	0.001	0.000	0.0000	0.0000	0.0000	0.0004	0.0000
81/06/30, 07:45 to 81/06/30, 08:00	0.5	0.001	0.000	0.001	0.000	0.0000	0.0000	0.0000	0.0003	0.0000
81/06/30, 08:00 to 81/06/30, 08:15	33.4	1.403	2.308	0.368	0.011	0.0023	0.0004	0.0027	0.1002	0.0068
81/06/30, 08:15 to 81/06/30, 08:30	21.2	0.339	0.673	0.191	0.021	0.0029	0.0006	0.0023	0.0310	0.0024
81/06/30, 08:30 to 81/06/30, 08:45	3.4	0.020	0.069	0.027	0.000	0.0001	0.0000	0.0001	0.0032	0.0003
81/06/30, 08:45 to 81/06/30, 09:00	2.6	0.016	0.063	0.013	0.000	0.0001	0.0000	0.0001	0.0023	0.0002
81/06/30, 09:00 to 81/06/30, 09:15	3.8	0.027	0.108	0.030	0.001	0.0001	0.0000	0.0002	0.0044	0.0480
81/06/30, 09:15 to 81/06/30, 09:30	8.4	0.151	0.403	0.143	0.003	0.0005	0.0002	0.0005	0.0158	0.0022
81/06/30, 09:30 to 81/06/30, 09:45	21.0	0.294	0.756	0.231	0.008	0.0013	0.0004	0.0013	0.0309	0.0035
81/06/30, 09:45 to 81/06/30, 10:00	9.9	0.069	0.242	0.083	0.002	0.0004	0.0001	0.0006	0.0094	0.0009
81/06/30, 10:00 to 81/06/30, 10:15	3.5	0.014	0.056	0.023	0.000	0.0001	0.0000	0.0002	0.0036	0.0002
81/06/30, 10:15 to 81/06/30, 10:30	2.9	0.009	0.046	0.020	0.000	0.0001	0.0000	0.0002	0.0020	0.0002
81/06/30, 08:00 to 81/06/30, 12:00	122.1	STORM VOLUME								
81/07/06, 20:30 to 81/07/06, 20:45	183.9	11.218	7.172	2.207	0.326	0.0261	0.0074	0.0276	0.3770	0.0210
81/07/06, 20:45 to 81/07/06, 21:00	112.3	4.380	4.380	0.736	0.173	0.0170	0.0034	0.0213	0.2460	0.0113
81/07/06, 21:00 to 81/07/06, 21:15	73.1	0.377	1.301	0.566	0.139	0.0048	0.0015	0.0080	0.1104	0.0053
81/07/06, 21:15 to 81/07/06, 21:30	75.4	0.905	1.960	0.377	0.051	0.0041	0.0015	0.0083	0.1073	0.0055
81/07/06, 21:30 to 81/07/06, 21:45	51.5	0.164	0.376	0.253	0.014	0.0020	0.0005	0.0052	0.0675	0.0033
81/07/06, 21:45 to 81/07/06, 22:00	54.6	0.437	0.923	0.273	0.022	0.0027	0.0005	0.0049	0.0650	0.0033
81/07/06, 22:00 to 81/07/06, 22:15	45.6	0.410	0.775	0.228	0.018	0.0025	0.0027	0.0068	0.0661	0.0027
81/07/06, 22:15 to 81/07/06, 22:30	34.1	0.205	0.580	0.171	0.009	0.0015	0.0003	0.0034	0.0409	0.0018
81/07/06, 19:00 to 81/07/07, 19:17	1706.0	ENTIRE STORM								

TABLE 13 (Continued)

Sampling Duration	Total Flow (m³)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/08/20, 06:30 to 81/08/20, 06:45	33.9	0.817	2.237	0.256	0.016	0.0023	0.0027	0.0109	0.1167	0.0073
81/08/20, 06:45 to 81/08/20, 07:00	28.4	0.284	1.551	0.653	0.010	0.0024	0.0011	0.0071	0.0852	0.0045
81/08/20, 07:00 to 81/08/20, 07:15	23.6	0.139	1.189	0.543	0.007	0.0019	0.0009	0.0104	0.0708	0.0034
81/08/20, 07:15 to 81/08/20, 07:30	24.2	0.218	1.423	0.581	0.007	0.0017	0.0007	0.0100	0.0968	0.0036
81/08/20, 07:30 to 81/08/20, 07:45	25.0	0.132	1.420	0.598	0.005	0.0012	0.0008	0.0038	0.0510	0.0031
81/08/20, 07:45 to 81/08/20, 08:00	12.2	0.073	0.615	0.256	0.003	0.0005	0.0005	0.0033	0.0488	0.0012
81/08/20, 03:30 to 81/08/20, 18:00	787.2	ENTIRE STORM								
81/08/25, 06:00 to 81/08/25, 06:15	36.2	0.434	1.915	0.688	0.018	0.0083	0.0018	0.0040	0.1086	0.0043
81/08/25, 06:15 to 81/08/25, 06:30	19.3	0.270	0.942	0.323	0.008	0.0042	0.0006	0.0023	0.0579	0.0023
81/08/25, 06:30 to 81/08/25, 06:45	17.9	0.125	0.729	0.251	0.003	0.0035	0.0002	0.0016	0.0222	0.0018
81/08/25, 06:45 to 81/08/25, 07:00	22.3	0.150	1.113	0.342	0.003	0.0011	0.0002	0.0032	0.0404	0.0024
81/08/25, 07:00 to 81/08/25, 07:15	15.3	0.111	0.578	0.237	0.002	0.0007	0.0003	0.0016	0.0155	0.0014
81/08/25, 07:15 to 81/08/25, 07:30	8.2	0.066	0.300	0.115	0.001	0.0004	0.0001	0.0007	0.0130	0.0008
81/08/25, 07:30 to 81/08/25, 07:45	30.9	0.247	1.004	0.433	0.004	0.0013	0.0009	0.0034	0.0927	0.0046
81/08/25, 07:45 to 81/08/25, 08:00	22.9	0.664	1.400	0.339	0.005	0.0029	0.0007	0.0027	0.0302	0.0031
81/08/25, 08:00 to 81/08/25, 08:15	27.3	9.503	7.362	1.512	[illegible]	0.0302	0.0056	0.0378	0.1390	0.0323
81/08/25, 08:15 to 81/08/25, 08:30	52.3	13.731	7.709	2.059	0.737	0.0933	0.0190	0.0829	0.2112	0.0327
81/08/25, 08:30 to 81/08/25, 08:45	49.3	0.543	1.419	0.548	0.010	0.0025	0.0005	0.0035	0.0742	0.0036
81/08/25, 08:45 to 81/08/25, 09:00	51.0	0.553	1.658	0.459	0.015	0.0036	0.0005	0.0041	0.0785	0.0040
81/08/25, 04:00 to 81/08/25, 14:00	681.0	ENTIRE STORM								
81/08/31, 10:00 to 81/08/31, 10:15	0.9	0.002	0.021	0.006	0.000	0.0000	0.0000	0.0001	0.0009	0.0000
81/08/31, 10:15 to 81/08/31, 10:30	6.2	0.254	0.632	0.186	0.010	0.0007	0.0014	0.0011	0.0248	0.0018
81/08/31, 10:30 to 81/08/31, 10:45	12.1	0.581	1.331	0.363	0.017	0.0028	0.0006	0.0019	0.0605	0.0049
81/08/31, 10:45 to 81/08/31, 11:00	2.8	0.050	0.207	0.073	0.001	0.0005	0.0001	0.0003	0.0084	0.0005
81/08.31, 11:00 to 81/08/31, 11:15	1.3	0.013	0.067	0.021	0.000	0.0001	0.0000	0.0001	0.0022	0.0001
81/08/31, 11:15 to 81/08/31, 11:30	1.6	0.006	0.038	0.013	0.000	0.0000	0.0000	0.0001	0.0014	0.0001
81/08/31, 11:30 to 81/08/31, 11:45	1.6	0.008	0.057	0.021	0.000	0.0001	0.0000	0.0001	0.0021	0.0002
81/08/31, 11:45 to 81/08/31, 12:00	3.1	0.034	0.171	0.053	0.001	0.0002	0.0001	0.0004	0.0058	0.0005
81/08/31, 12:00 to 81/08/31, 12:15	6.8	0.068	0.347	0.116	0.001	0.0007	0.0002	0.0005	0.0112	0.0012
81/08/31, 12:15 to 81/08/31, 12:30	4.0	0.024	0.139	0.064	0.001	0.0002	0.0001	0.0004	0.0060	0.0005
81/08/31, 12:30 to 81/08/31, 12:45	1.5	0.009	0.065	0.021	0.000	0.0001	0.0000	0.0001	0.0021	0.0002
81/08/31, 12:45 to 81/08/31, 13:00	1.1	0.004	0.035	0.012	0.000	0.0000	0.0000	0.0001	0.0014	0.0001
81/08/31, 13:00 to 81/08/31, 21:00	132.1	3.170	3.646	1.321	0.012	0.0066	0.0040	0.0200	0.3963	0.0125
81/08/31, 21:00 to 81/08/31, 24:00	17.6	0.141	0.415	0.088	0.002	0.0004	0.0002	0.0019	0.0310	0.0008
81/08/31, 10:00 to 81/08/31, 24:00	828.4	TOTAL STORM FLOW								
81/09/01, 00:01 to 81/09/01, 03:00	129.3	1.293	3.569	0.905	0.016	0.0026	0.0021	0.0103	0.2043	0.0069
81/09/01, 03:00 to 81/09/01, 06:00	15.4	0.108	0.425	0.077	0.001	0.0002	0.0002	0.0015	0.0242	0.0005

TABLE 13 (Continued)

Sampling Duration	Total Flow (m^3)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/09/21, 16:45 to 81/09/21, 17:00	0.9	0.004	0.018	0.005	0.000	0.0000	0.0000	0.0001	0.0018	0.0000
81/09/21, 17:00 to 81/09/21, 17:15	39.9	2.753	2.119	0.713	0.032	0.0070	0.0008	0.0056	0.1197	0.0021
81/09/21, 17:15 to 81/09/21, 17:30	51.2	0.270	1.574	0.358	0.025	0.0055	0.0015	0.0061	0.0701	0.0021
81/09/21, 17:30 to 81/09/21, 17:45	13.3	0.041	0.231	0.097	0.003	0.0005	0.0003	0.0012	0.0149	0.0005
81/09.21, 17:45 to 81/09/21, 18:00	6.3	0.041	0.139	0.054	0.001	0.0002	0.0002	0.0008	0.0071	0.0003
81/09/21, 18:00 to 81/09/21, 18:15	6.8	0.054	0.194	0.054	0.001	0.0003	0.0001	0.0010	0.0065	0.0006
81/09/21, 16:45 to 81/09/21, 23:00	170.5	ENTIRE STORM								
81/09/28, 02:00 to 81/09/28, 04:00	61.4	BEGINNING OF STORM								
81/09/28, 06:00 to 81/09/28, 06:15	21.3	0.064	0.256	0.085	0.001	0.0003	0.0002	0.0030	0.0170	0.0004
81/09/28, 06:15 to 81/09/28, 06:30	34.0	0.102	0.408	0.136	0.002	0.0005	0.0004	0.0048	0.0272	0.0007
81/09/28, 06:30 to 81/09/28, 06:45	30.7	0.092	0.368	0.092	0.002	0.0004	0.0007	0.0083	0.0181	0.0007
81/09/28, 06:45 to 81/09/28, 07:00	21.7	0.037	<0.217	0.065	0.001	0.0003	0.0002	0.0024	0.0130	0.0004
81/09/28, 07:00 to 81/09/28, 07:15	16.7	0.067	0.200	0.050	0.001	0.0002	0.0002	0.0023	0.0110	0.0004
81/09/28, 07:15 to 81/09/28, 07:30	15.7	0.047	0.251	0.063	0.001	0.0002	0.0002	0.0024	0.0105	0.0004
81/09/28, 07:30 to 81/09/28, 07:45	9.1	0.027	0.109	0.036	0.000	0.0001	0.0001	0.0011	0.0064	0.0002
81/09/28, 07:45 to 81/09/28, 08:00	6.3	0.013	0.076	0.025	0.000	0.0001	0.0001	0.0013	0.0048	0.0001
81/09/28, 08:00 to 81/09/28, 08:15	5.0	0.010	<0.050	0.015	0.000	0.0001	0.0000	0.0013	0.0036	0.0001
81/09/28, 08:15 to 81/09/28, 08:30	5.6	0.017	0.067	0.022	0.011	0.0001	0.0001	0.0007	0.0047	0.0001
81/09/28, 08:30 to 81/09/28, 08:45	7.4	0.030	0.089	0.030	0.000	0.0001	0.0001	0.0009	0.0054	0.0002
81/09/28, 08:45 to 81/09/28, 09:00	5.8	0.017	0.070	0.023	0.000	0.0001	0.0001	0.0008	0.0045	0.0001
81/09/28, 04:00 to 81/09/28, 09:30	423.8									
81/09/28, 02:00 to 81/09/28, 11:00	506.1									
81/09/30, 00:00 to 81/09/30, 05:30	458.7	BEGINNING OF STORM								
81/09/30, 05:30 to 81/09/30, 05:45	12.8	0.038	<0.001	0.051	0.001	0.0002	0.0002	0.0023	0.0095	0.0003
81/09/30, 05:45 to 81/09/30, 06:00	8.8	0.013	<0.001	0.035	0.001	0.0001	0.0001	0.0014	0.0065	0 0003
81/09/30, 06:00 to 81/09/30, 06:15	6.6	0.013	<0.001	0.026	0.001	0.0001	0.0001	0.0010	0.0053	0.0002
81/09.30, 06:15 to 81/09/30, 06:30	7.4	0.022	<0.001	0.030	0.001	0.0001	0.0001	0.0010	0.0065	0.0002
81/09/30, 06:30 to 81/09/30, 06:45	8.6	0.026	<0.001	0.034	0.001	0.0001	0.0001	0.0014	0.0077	0.0003
81/09/30, 06:45 to 81/09/30, 07:00	7.0	0.014	0.092	0.028	0.001	0.0001	0.0001	0.0009	0.0073	0.0002
81/09/30, 07:00 to 81/09/30, 11:15	60.5	END OF STORM								
81/09/30, 00:00 to 81/09/30, 11:15	570.7	ENTIRE STORM								

TABLE 13 (Continued)

Sampling Duration	Total Flow (m³)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/10/01, 02:00 to 81/10/01, 09:30	1015.6	BEGINNING OF STORM								
81/10/01, 09:30 to 81/10/01, 09:45	49.7	0.249	0.646	0.149	0.005	0.0013	0.0007	0.0045	0.0542	0.0015
81/10/01, 09:45 to 81/10/01, 10:00	50.9	0.204	0.662	0.204	0.006	0.0013	0.0008	0.0056	0.1018	0.0017
81/10/01, 10:00 to 81/10/01, 10:15	60.7	0.301	1.050	0.304	0.006	0.0014	0.0007	0.0067	0.1321	0.0022
81/10/01, 10:15 to 81/10/01, 10:30	76.0	0.532	1.315	0.380	0.008	0.0021	0.0010	0.0068	0.2230	0.0027
81/10/01, 10:30 to 81/10/01, 10:45	69.4	0.555	1.201	0.273	0.006	0.0021	0.0010	0.0062	0.1388	0.0026
81/10/01, 10:45 to 81/10/01, 11:00	65.0	0.390	0.345	0.260	0.005	0.0014	0.0006	0.0052	0.0741	0.0020
81/10/01, 11:00 to 81/10/01, 11:15	52.0	0.364	0.676	0.208	0.005	0.0015	0.0005	0.0047	0.0515	0.0015
81/10/01, 11:15 to 81/10/01, 11:30	49.2	0.314	0.640	0.118	0.005	0.0011	0.0010	0.0040	0.0537	0.0016
81/10/01, 11:30 to 81/10/01, 11:45	47.3	0.331	0.615	0.119	0.004	0.0015	0.0006	0.0039	0.0562	0.0513
81/10/01, 11:45 to 81/10/01, 12:00	39.9	0.200	0.519	0.160	0.003	0.0008	0.0003	0.0032	0.0475	0.0013
81/10/01, 12:00 to 81/10/01, 12:15	35.3	0.212	0.459	0.141	0.004	0.0009	0.0002	0.0023	0.0455	0.0012
81/10/01, 12:15 to 81/10/01, 12:30	40.6	0.203	0.523	0.122	0.004	0.0012	0.0004	0.0032	0.0544	0.0013
81/10/02, 02:00 to 81/10/02, 07:00	3815.0	TOTAL STORM								
81/10/05, 01:00 to 81/10/05, 12:00	53.6	BEGINNING OF STORM								
81/10/05, 12:00 to 81/10/05, 14:30	141.1	BEGINNING OF STORM								
81/10/05, 14:30 to 81/10/05, 14:45	5.5	0.021	0.094	0.017	0.001	0.0001	0.0001	0.0007	0.0072	0.0002
81/10/05, 14:45 to 81/10/05, 15:00	40.0	0.120	0.512	0.120	0.004	0.0006	0.0003	0.0044	0.0424	0.0014
81/10/05, 15:00 to 81/10/05, 15:15	52.0	1.161	1.354	0.217	0.026	0.0063	0.0006	0.0079	0.0534	0.0039
81/10/05, 15:15 to 81/10/05, 15:30	25.0	0.375	0.428	0.100	0.006	0.0019	0.0002	0.0012	0.0193	0.0017
81/10/05, 15:30 to 81/10/05, 15:45	13.9	0.070	0.178	0.042	0.002	0.0004	0.0001	0.0008	0.0075	0.0006
81/10/05, 15:45 to 81/10/05, 16:00	12.1	0.061	0.155	0.036	0.001	0.0004	0.0001	0.0012	0.0093	0.0004
81/10/05, 14:30 to 81/10/05, 18:00	197.4	ENTIRE STORM								
81/10/26, 14:00 to 81/10/26, 14:15	1.5	BEGINNING OF STORM								
81/10/26, 14:15 to 81/10/26, 14:30	1.6	0.006	0.029	0.308	0.000	0.0000	0.0000	0.0001	0.0019	0.0001
81/10/26, 14:30 to 81/10/26, 14:45	1.6	0.152	<0.016	0.006	0.000	0.0000	0.0000	0.0001	0.0048	0.0001
81/10/26, 14:45 to 81/10/26, 15:00	1.7	0.039	0.036	0.015	0.001	0.0001	0.0000	0.0001	0.0014	0.0000
81/10/26, 15:00 to 81/10/26, 15:15	2.1	0.143	0.163	0.050	0.001	0.0003	0.0001	0.0003	0.0063	0.0000
81/10/26, 15:15 to 81/10/26, 15:30	3.1	0.482	0.357	0.112	0.002	0.0004	0.0001	0.0005	0.0102	0.0001
81/10/26, 15:30 to 81/10/26, 15:45	5.3	0.360	0.530	0.175	0.003	0.0005	0.0002	0.0007	0.0159	0.0003
81/10/26, 15:45 to 81/10/26, 16:00	17.4	1.036	1.730	0.593	0.000	0.0024	0.0007	0.0024	0.0522	0.0011
81/10/26, 16:00 to 81/10/26, 16:15	19.8	0.059	5.060	1.822	0.012	0.0038	0.0010	0.0022	0.0099	0.0003
81/10/26, 16:15 to 81/10/26, 16:30	20.3	0.399	1.329	2.571	0.007	0.0025	0.0006	0.0019	0.0264	0.0018
81/10/26, 16:30 to 81/10/26, 16:45	24.2	0.532	0.995	0.315	0.007	0.0031	0.0005	0.0015	0.0225	0.0021
81/10/26, 16:45 to 81/10/26, 17:00	16.7	0.317	0.610	0.200	0.005	0.0022	0.0003	0.0012	0.0157	0.0013
81/10/26, 17:00 to 81/10/26, 17:15	12.7	0.178	0.406	0.114	0.003	0.0010	0.0003	0.0011	0.0100	0.0009
81/10/26, 14:00 to 81/10/26, 19:00	188.5	TOTAL STORM FLOW								

TABLE 13 (Continued)

Sampling Duration	Total Flow (m³)	Loading (kg)								
		Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/11/11, 00:24 to 81/11/11, 04:45	195.0		BEGINNING OF STORM							
81/11/11, 04:45 to 81/11/11, 05:00	38.4	0.567	1.340	0.234	0.010	0.0019	0.0008	0.0023	0.0323	0.00415
81/11/11, 05:00 to 81/11/11, 05:15	39.9	0.479	1.221	0.319	0.009	0.0016	0.0008	0.0024	0.0339	0.00333
81/11/11, 05:15 to 81/11/11, 05:30	42.1	0.463	0.834	0.337	0.008	0.0017	0.0004	0.0030	0.0236	0.00337
81/11/11, 05:30 to 81/11/11, 05:45	53.9	0.362	1.517	0.377	0.017	0.0027	0.0011	0.0038	0.0361	0.00453
81/11/11, 05:45 to 81/11/11, 06:00	51.7	0.520	1.344	0.262	0.017	0.0025	0.0010	0.0041	0.0294	0.00408
81/11/11, 06:00 to 81/11/11, 06:15	52.1	0.573	1.094	0.251	0.014	0.0023	0.0010	0.0042	0.0276	0.01376
81/11/11, 06:15 to 81/11/11, 11:19	224.3		END OF STORM							
81/11/11, 00:24 to 81/11/11, 11:19	719.0		TOTAL STORM FLOW							
81/11/15, 13:30 to 81/11/15, 14:00	21.0	BEGINNING OF STORM								
81/11/15, 14:00 to 81/11/15, 14:15	18.2	0.473	0.712	0.213	0.011	0.0020	0.0004	0.0016	0.0236	0.0023
81/11/15, 14:15 to 81/11/15, 14:30	18.1	0.272	0.630	0.217	0.007	0.0018	0.0004	0.0013	0.0212	0.0013
81/11/15, 14:30 to 81/11/15, 14:45	16.3	0.259	12.415	3.364	0.007	0.0025	0.0002	0.0013	0.0176	0.0083
81/11/15, 14:45 to 81/11/15, 15:00	13.8	0.179	2.042	0.621	0.006	0.0012	0.0003	0.0010	0.0132	0.0022
81/11/15, 15:00 to 81/11/15, 15:15	17.0	0.137	1.329	0.425	0.007	0.0017	0.0001	0.0010	0.0162	0.0013
81/11/15, 15:15 to 81/11/15, 15:30	18.3	0.201	0.955	0.311	0.009	0.0020	0.0001	0.0013	0.0167	0.0015
81/11/15, 15:30 to 81/11/15, 15:45	19.0	0.171	0.578	0.152	0.006	0.0008	0.0004	0.0013	0.0169	0.0010
81/11/15, 15:45 to 81/11/15, 16:00	23.0	0.376	0.627	0.173	0.010	0.0010	0.0006	0.0020	0.0225	0.0015
81/11/15, 16:00 to 81/11/15, 16:15	33.1	0.530	0.718	0.255	0.011	0.0013	0.0007	0.0020	0.0136	0.0020
81/11/15, 16:15 to 81/11/15, 16:30	34.4	0.482	0.746	0.206	0.012	0.0017	0.0002	0.0021	0.0261	0.0020
81/11/15, 16:30 to 81/11/15, 16:45	41.3	0.413	0.719	0.207	0.011	0.0017	0.0003	0.0033	0.0256	0.0018
81/11/15, 16:45 to 81/11/15, 17:00	42.1	0.324	1.099	0.211	0.024	0.0038	0.0008	0.0024	0.0282	0.0025
81/11/30, 12:15 to 81/11/30, 12:30	24.0	0.192	0.420	0.096	0.005	0.0007	0.0005	0.0026	0.0146	0.0008
81/11/30, 12:30 to 81/11/30, 12:45	24.8	0.124	0.327	0.099	0.003	0.0007	0.0001	0.0025	0.0166	0.0007
81/11/30, 12:45 to 81/11/30, 13:00	27.2	0.163	0.359	0.032	0.006	0.0007	0.0005	0.0024	0.0182	0.0010
81/11/30, 13:00 to 81/11/30, 13:15	31.0	0.136	0.409	0.033	0.006	0.0011	0.0002	0.0031	0.0130	0.0009
81/11/30, 13:15 to 81/11/30, 13:30	36.3	0.436	0.955	0.145	0.017	0.0020	0.0003	0.0033	0.0200	0.0014
81/11/30, 13:30 to 81/11/30, 13:45	40.2	0.304	1.234	0.362	0.013	0.0028	0.0008	0.0072	0.0318	0.0020
TOTAL	8831.1	201.634	216.849	66.424	4.267	0.5237	0.3345	1.0853	13.6938	1.4190
Flow-Weighted Mean Concentration (mg/L)		22.33	24.56	7.52	0.48	0.059	0.038	0.123	1.55	0.161
Mean 15 Minute Interval Load (All Storms)		0.463	0.659	0.199	0.013	0.0017	0.0007	0.0027	0.0328	0.0041
Extrapolated Average Daily Load (All Storms)		44.47	63.21	19.07	1.21	0.164	0.071	0.26	3.15	0.396

TABLE 14

BIOASSAY DATA SUMMARY
(RAINBOW TROUT)

Collection		Testing Started		Initial		No. of Fish	Effluent Concentration	Effluent pH	Dilution Water		Loading Density (gm/L)	Fork Length (cm)		Weight (gm)	
Date	Time	Date	Time	pH	DO				pH	Hardness		Average	Range	Average	Range
80/06/12*	10:30	80/06/12	15:15	6.4	10.2	6	100%	7.9	6.4	≈4.5	0.5	5.9	5.1-6.6	2.4	1.7-3.4
80/06/20*+	09:30	80/06/20	13:05	7.7	9.7	7	100%	7.7	6.2	≈4.5	0.5	6.0	5.4-6.5	2.2	1.6-2.9
80/06/25	14:15	80/06/26	14:15	7.0	10.0	6	100%	6.3	6.2	≈4.5	0.5	6.0	5.1-6.6	2.4	1.7-3.4
80/11/04	14:30	80/11/05	-	7.0	9.9	6	100%	7.0	6.4	5.6	0.5	6.0	5.2-7.2	2.6	1.7-4.3
81/01/29	09:00	81/01/29	16:00	6.8	12.0	10	100%	6.3	6.3	≈4.1	0.9	5.3	5.4-6.2	1.9	1.6-2.6
81/01/29	09:15	81/01/29	16:00	6.9	12.0	10	100%	6.9	6.3	≈4.1	0.9	5.3	5.4-6.2	1.9	1.6-2.6
81/01/29	09:30	81/01/29	16:00	6.8	12.0	10	100%	6.8	6.3	≈4.1	0.9	5.8	5.4-6.2	1.9	1.6-2.6
81/01/29	09:45	81/01/29	16:00	6.3	12.0	10	100%	6.8	6.3	≈4.1	0.9	5.8	5.4-6.2	1.9	1.6-2.6
81/04/21	08:00	81/04/21	-	6.5	9.7	10	100%	6.5	6.5	3.3	1.0	5.8	5.2-6.4	2.2	1.5-2.9
81/04/21	08:15	81/04/21	-	6.3	9.5	10	100%	6.8	6.4	3.3	1.0	5.3	5.2-6.4	2.2	1.5-2.9
81/04/21	08:30	81/04/21	-	6.8	11.0	10	100%	6.8	6.4	3.8	1.0	5.8	5.2-6.4	2.2	1.5-2.9
81/04/21	08:45	81/04/21	-	6.3	10.5	10	100%	6.8	6.4	3.8	1.0	5.8	5.2-6.4	2.2	1.5-2.9
81/10/05	10:30	81/10/06	12:00	7.1	10.1	10	100%	7.1	6.3	≈4.1	0.3	4.0	3.2-4.6	0.5	0.3-1.0
81/10/05	10:45	81/10/06	12:00	7.0	10.1	10	100%	7.0	6.3	≈4.1	0.3	4.0	3.2-4.6	0.5	0.3-1.0
81/10/05	11:00	81/10/06	12:00	7.5	10.2	10	100%	7.5	6.3	≈4.1	0.3	4.0	3.2-4.6	0.5	0.3-1.0
81/10/05	11:15	81/10/06	12:00	6.9	10.2	10	100%	6.9	6.3	≈4.1	0.3	4.0	3.2-4.6	0.5	0.3-1.0
81/10/05	11:30	81/10/06	12:00	7.0	10.2	10	100%	7.0	6.3	≈4.1	0.3	4.0	3.2-4.6	0.5	0.3-1.0

* Dry Weather Sample

+ No mortalities reported at lesser concentrations (63%, 40%, 25%)

Notes:
- Dilutions measured by weight of whole sample
- Dilution water was fresh water
- Fish sizes are weekly averages
- Bioassay temperature 15° ± 1°C
- Hardness measured as mg/L $CaCO_3$
- Analyses performed at Environment Canada, Environmental Protection Service, Environmental Toxicology Laboratory, North Vancouver, B.C.

TABLE 14 (Continued)

Collection		Testing Started		Cumulative Mortality at Time (Hrs)				Final		96h LC50
Date	Time	Date	Time	24	48	72	96	pH	DO	
80/06/12*	10:30	80/06/12	15:15	0	0	0	0	8.1	10.2	>100%
80/06/20*+	09:30	80/06/20	13:05	1	1	1	1	7.9	9.8	>100%
80/06/25	14:15	80/06/26	14:15	0	0	0	0	7.1	10.0	>100%
80/11/04	14:30	80/11/05	-	0	0	0	0	7.5	9.3	>100%
81/01/29	09:00	81/01/29	16:00	0	0	0	0	6.9	9.3	>100%
81/01/29	09:15	81/01/29	16:00	0	0	0	0	6.8	7.8	>100%
81/01/29	09:30	81/01/29	16:00	0	0	0	0	6.5	4.6	>100%
81/01/29	09:45	81/01/29	16:00	0	0	0	0	6.9	8.7	>100%
81/04/21	08:00	81/04/21	-	0	0	0	0	6.9	9.7	>100%
81/04/21	08:15	81/04/21	-	0	0	0	0	7.0	9.8	>100%
81/04/21	08:30	81/04/21	-	0	0	0	0	7.0	9.5	>100%
81/04/21	08:45	81/04/21	-	0	0	0	0	7.0	9.9	>100%
81/10/05	10:30	81/10/06	12:00	0	0	0	0	7.3	10.0	>100%
81/10/05	10:45	81/10/06	12:00	0	0	0	0	7.2	10.0	>100%
81/10/05	11:00	81/10/06	12:00	0	0	0	0	7.2	9.7	>100%
81/10/05	11:15	81/10/06	12:00	0	0	0	0	7.1	9.8	>100%
81/10/05	11:30	81/10/06	12:00	0	0	0	0	7.2	9.9	>100%

* Dry Weather Sample

+ No mortalities reported at lesser concentrations (63%, 40%, 25%)

Notes: - Dilutions measured by weight of whole sample
- Dilution water was fresh water
- Fish sizes are weekly averages
- Bioassay temperature 15° 1°C
- Hardness measured as mg/L $CaCO_3$
- Analyses performed at Environment Canada, Environmental Protection Service, Environmental Toxicology Laboratory, North Vancouver, B.C.

TABLE 15

DAPHNIA BIOASSAY DATA SUMMARY

Jar	Effluent Concentration %	Cumulative Mortality at Time (Hrs) 24	48	96	% Dead	Average % Dead
1a	56	0	1	4	80	86.7
1b		0	2	5	100	
1c		1	1	4	80	
2a	32	0	0	2	40	40
2b		0	0	3	60	
2c		0	1	1	20	
3a	18	0	0	1	20	20
3b		0	0	0	0	
3c		0	0	2	40	
4a	10	0	0	1	20	26.7
4b		0	0	3	60	
4c		0	0	0	0	
5a	5.6	0	0	0	0	6.7
5b		0	0	0	0	
5c		0	0	1	20	
6a	3.2	0	0	3	60	20
6b		0	0	0	0	
6c		0	0	0	0	
7a	1.8	0	0	0	0	13.3
7b		0	0	0	0	
7c		0	0	2	40	
8a	1.0	0	0	0	0	0
8b		0	0	0	0	
8c		0	0	0	0	
9a	control - 100% dilution water	0	0	0	0	0
9b		0	0	0	0	
9c		0	0	0	0	

Notes: (1) Analyses performed by Mr. B.C. Anderson, University of British Columbia, Civil Engineering Department.

(2) Sample collected August 26, 1980.

(3) Bioassay was carried out using a 1:1 mixture of preserved (<5% HNO_3) and unpreserved sample which was brought back to initial pH (7.21) using ≈5 N NaOH.

(4) Test organism was neonate *Daphnia magna* (<24 hours old) placed 5 to a jar in wide mouth flint glass 100 mL jars and exposed to a series of dilutions of the effluent with dilution water from Deer Lake.

TABLE 16

TRACE METAL ANALYSES FOR EFFLUENT USED IN DAPHNIA BIOASSAY

Trace Metal	Effluent Concentration (mg/L)	Blank Concentration (mg/L)	Total Effluent Concentration (mg/L)
Cadmium	<0.004	N.D.	<0.004
Calcium	9.6	N.D.	9.6
Chromium	<0.004	N.D.	<0.004
Copper	0.072	0.082	0.154
Iron	0.152	N.D.	0.152
Lead	0.056	N.D.	0.056
Nickel	0.020	N.D.	0.020
Magnesium	0.66	N.D.	0.66
Zinc	0.055	0.015	0.070

N.D. = not detectable

TABLE 17

ANALYSIS OF ACCUMULATED GRIT AND SEDIMENT DEPOSITED IN THE FLUME

Parameter	Date				Mean
	Sept. 25, 1981	Oct. 5, 1981*	Nov. 4, 1981†	Nov. 12, 1981†	
Aluminum mg/g Dry			8.02	4.60	6.31
Cadmium µg/g Dry			19	<1	-
Copper µg/g Dry	26	25	29	22	25.5
Iron mg/g Dry	12.9	13.4	12.2	11	12.4
Lead µg/g Dry	209	182	160	170	180
Manganese µg/g Dry			210	195	203
Mercury µg/g @ 20°C			<0.05	-	-
Zinc µg/g Dry	167	183	101	110	140
Polychlorinated Biphenyls					
Arochlor 1242 µg/g @ 20°C	0.19	<0.02	0.13	<0.02	-
Arochlor 1254 µg/g @ 20°C	<0.02	<0.02	<0.02	<0.02	-
Arochlor 1260 µg/g @ 20°C	0.14	<0.02	0.45	<0.02	-

* Sediment deposited in period September 29, 1981 to October 5, 1981.

† Sediment deposited since last date sampled.

TABLE 18

METAL VALUES IN THE SUSPENDED FRACTION*

SEPTEMBER 30, 1981

Values**

Sample Number	Suspended Solids	Fixed Suspended Solids	Copper	Iron	Lead	Zinc
1	3	2	0.001	0.00	0.009	0.01
2	2	1	0.001	0.00	0.004	0.00
3	2	1	0.002	0.00	0.004	0.04
4	3	1	0.009	0.03	0.004	0.03
5	3	1	0.005	0.05	0.006	0.07
6	2	1	0.005	0.08	0.009	0.03

OCTOBER 1, 1981

Values**

Sample Number	Suspended Solids	Fixed Suspended Solids	Copper	Iron	Lead	Zinc
1	5	2	0.009	<0.18	0.020	0.03
2	4	2	0.011	<0.19	0.021	0.03
3	5	2	0.006	<0.17	0.016	0.03
4	7	3	0.010	<0.20	0.021	0.04
5	8	4	0.012	<0.24	0.024	0.03
6	6	3	0.007	<0.18	0.013	0.03
7	7	3	0.006	<0.19	0.025	0.03
8	7	3	0.012	<0.22	0.003	0.02
9	7	3	0.010	<0.16	0.026	0.02
10	5	2	0.004	<0.17	0.014	0.01
11	6	3	<0.008	<0.20	0.019	0.02
12	5	2	<0.011	<0.20	0.023	0.02

NOVEMBER 10, 1981 LOW FLOW

Values**

Sample Number	Suspended Solids	Fixed Suspended Solids	Copper	Iron	Lead	Zinc
1	46	30	0.00	5.33	0.001	0.00
2	46	31	0.01	7.30	<0.001	0.03
3	45	29	0.02	7.73	0.036	0.07
4	36	23	0.01	3.15	<0.001	0.00
5	43	27	0.02	4.98	0.086	0.05
6	38	21	0.00	2.24	0.080	0.01

TABLE 18 (CONT'D)

NOVEMBER 10, 1981

		Values**
Sample Number	Manganese	Aluminum
1	0.04	1.63
2	0.09	1.70
3	0.12	1.53
4	0.04	-
5	0.12	1.19
6	0.03	1.13

NOVEMBER 11, 1981 HIGH FLOW

		Values**				
Sample Number	Suspended Solids	Fixed Suspended Solids	Copper	Iron	Lead	Zinc
1	15	7	0.00	0.41	0.030	0.01
2	12	6	0.00	0.32	0.020	0.00
3	11	4	0.00	0.28	0.023	0.01
4	16	8	0.008	0.50	0.037	0.00
5	12	5	0.009	0.49	0.036	0.02
6	11	5	0.012	0.50	0.035	0.03

NOVEMBER 11, 1981

		Values**
Sample Number	Manganese	Aluminum
1	0.0	0.23
2	0.00	0.25
3	0.01	0.18
4	0.01	0.29
5	0.02	0.28
6	0.02	0.26

* total value minus dissolved value
** All values are as mg/L.

TABLE 19

REPORTED CONCENTRATIONS OF PARAMETERS FOR TWO AUSTRALIAN RESIDENTIAL-TYPE CATCHMENT AREAS(48)

Parameters	No. of Values	Values*		
		Maximum	Minimum	Mean
BOD_5	20	38	5	14
Coliform- fecal	17	110 000	100	7600+
Carbon - total organic	166	130	8	26.6
Metals:				
Cadmium	120	0.02	0.002	0.01
Chromium	120	0.03	0.007	0.022
Copper	120	0.31	0.009	0.063
Lead	121	2.8	0.03	0.40
Mercury	15	0.0001	0.0001	0.0001
Nickel	120	0.36	0.009	0.022
Zinc	121	4.4	0.02	0.95
Nitrogen:				
Ammonia	194	5.6	0.02	0.40
Nitrite	70	0.39	0.006	0.055
Nitrate	88	50	0.25	5.9
Total Kjeldahl	177	14	0.7	2.57
Phosphorus:				
Total	190	1.35	0.104	0.35
Ortho	78	0.63	0.05	0.186
Suspended Solids	173	1600	14	183

+ Median

* All values are mg/L except fecal coliform which are as MPN/100 mL.

TABLE 20

TRENDS OF CONCENTRATIONS THROUGHOUT INDIVIDUAL STORMS*

	Date	January 20/21, 1981		January 28, 1981		January 29, 1981		February 12, 1981		February 16, 1981	
	Sample			07:00 - 08:30		09:00 - 10:30		08:00 - 09:30		15:30 - 17:00	
	Constituent	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value
TRENDS OF CONCENTRATIONS	Suspended Solids	followed flow	40	no real trend	53	followed flow	52	dec./inc. flow	130	followed flow	17
	Metals: Aluminum	followed flow	0.6	followed flow	1.05	followed flow	0.65	dec./inc. flow	1.25	followed flow	0.43
	Copper	inc./dec. flow	0.5	followed flow	0.015	followed flow	0.20	no real trend	0.05	followed flow	0.03
	Lead	followed flow	0.13	followed flow	0.20	followed flow	0.05	no real trend	0.14	followed flow	0.10
	Zinc	followed flow	0.2	followed flow	0.15	followed flow	0.15	no real trend	0.21	followed flow	0
	COD	followed flow	43	no real trend	50	no real trend	28	dec./inc. flow	52	usually at MDC	17
	TOC	followed flow	12	no real trend	20	followed flow	7	no real trend	15	no real trend	5
	Total Coliform	followed flow	>24000	no data collected	-	followed flow	15000	no real trend	>24000	no data collected	-
	Fecal Coliform	followed flow	>24000	no data collected	-	followed flow	9000	no real trend	>24000	no data collected	-
	Nitrogen - Total	followed flow	3	no real trend	3	no real trend	2	constant	3	inc./dec. flow	3
	- Organic	followed flow	2	no real trend	2	no real trend	2	constant	2	inc./dec. flow	2
	- Ammonia	followed flow at end	0.75	no real trend	0.4	no real trend	0.35	no real trend	≈0.3	constant	0
	- NO_2/NO_3	followed flow at end	0.4	no real trend	0.5	no real trend	0.50	no real trend	≈0.6	inc. with dec. flow	0.8
	Oil and Grease	followed flow	5.1	no real trend	16	no real trend	3.3	no real trend	5.4	no real trend	7.5
	Comments	No apparent 1st flusn.		No real trend in storm: sampled too early: small storm.		Middle of storm.		Storm sampled early.		Middle of storm.	

* Maximum values are estimated from graphs of storms, and bacteriological samples, when collected, were taken every 15 minutes for a 3 hour duration.

NOTES

(1) MDC = minimum detectable concentration.

(2) inc./dec. flow = increased with decreasing flow.

TABLE 20 (CONT'D)

	Date	February 17, 1981		February 13, 1981		February 26, 1981		March 3, 1981		March 24, 1981	
	Sample	15:30 - 17:00		19:15 - 20:15		08:00 - 09:30		10:15 - 15:15		22:30 - 24:00	
	Constituent	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value
TRENDS OF CONCENTRATIONS	Suspended Solids	followed flow	15	≈constant	13	followed flow	24	inc./dec. flow	80	dec./inc. flow	40
	Metals: Aluminum	followed flow	0.20	followed SS	0.35	followed flow	0.25	inc./dec. flow	0.6	dec./inc. flow	2.2
	Copper	≈constant	0.05	no real trend	0.06	followed flow	0.05	inc./dec. flow	0.35	no real trend	0.25
	Lead	followed flow	0.05	no real trend	0.10	followed flow	0.05	constant	0.05	followed flow	0.5
	Zinc	≈constant	0.05	no real trend	0.09	followed flow	0.10	≈constant	0.12	no real trend	0.75
	COD	followed flow	17	dec./inc. flow	17	followed flow	20	≈followed flow	32	dec./inc. flow	36
	TOC	followed flow	8	dec./inc. flow	5	no real trend	10	≈followed flow	8	dec./inc. flow	11
	Total Coliform	no data collected	-	no data collected	-	possibly followed flow	≈15000	no data collected	-	≈ constant	≈10000
	Fecal Coliform	no data collected	-	no data collected	-	possibly followed flow	≈15000	no data collected	-	inc. after 1st surge of flow came through	≈1000
	Nitrogen - Total										
	- Organic	dec./inc. flow	2.2	dec./inc. flow	2.5	dec./inc. flow	6	≈followed flow	3	no real pattern	2.5
	- Ammonia	followed flow	0.5	dec./inc. flow	1.35	dec./inc. flow	5	≈followed flow	2	no real pattern	2.0
	- NO_2/NO_3	≈constant	0.1	dec./inc. flow	0.15	dec./inc. flow	0.6	≈followed flow	0.4	dec./inc. flow	0.5
		dec./inc. flow	1.3	dec./inc. flow	0.97	dec./inc. flow	0.2	≈followed flow	0.6	≈constant	0.35
	Oil and Grease	no data collected	-	followed flow	10.0	followed flow	7	inc./dec. flow	11.6	followed flow	5
	Comments	Beginning of storm.		Beginning of storm.		After 1 flush. Analysis of a 2nd flush ≈ 2 hr after 1st.		Const. storm for ≈ 7 hrs then intense inc. for another 7 hrs. Sampling last 2 1/2 hrs of intense and 2 hrs thereafter.		Beginning of storm.	

TABLE 20 (CONT'D)

	Date	April 3, 1981		April 21, 1981		April 21/22, 1981		April 22, 1981		April 29, 1981	
	Sample	08:00 - 09:30		08:00 - 09:30		17:45 - 05:45		05:15 - 19:00		10:00 - 11:30	
TRENDS OF CONCENTRATIONS	Constituent	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value
	Suspended Solids	followed flow	15	followed flow	42	followed flow	50	≈constant	10	no real trend	17
	Metals: Aluminum	followed flow	0.25	followed flow	0.5	followed flow	0.20	no real trend	0.20	no real trend	0.18
	Copper	constant	0.0	no real trend	0.04	followed flow	0.02	increased	0.07	no real trend	0.05
	Lead	constant	0.0	followed flow	0.1	followed flow	0.03	≈constant	0.03	no real trend	0.04
	Zinc	constant	0.1	no real trend	0.14	followed flow	0.10	increased	0.10	followed flow	0.13
	COD	no real trend	15	no real trend	14	followed flow	13	constant	13.5	no real trend	30
	TOC	≈followed flow	4	no real trend	5	dec./inc. flow	6	≈constant	7	no real trend	6
	Total Coliform	≈followed flow	>24000	no real trend	≈10000	no data collected	-	no data collected	-	≈followed flow	>24000
	Fecal Coliform	≈followed flow	>24000		≈ 9000	no data collected	-	no data collected	-	≈followed flow	≈ 8000
	Nitrogen - Total	dec./inc. flow	2.0	followed flow	1.4	no real trend	3.0	no real trend	2.9	no real trend	2.0
	- Organic	inc./dec. flow	0.5	no real trend	0.6	no real trend	3.0	no real trend	1.3	no real trend	1.0
	- Ammonia	dec./inc. flow	0.2	decreased	0.25	no real trend	0.5	no real trend	0.5	no real trend	1.0
	- NO_2/NO_3	dec./inc. flow	0.5	followed flow	0.5	no real trend	1.6	no real trend	2.0	no real trend	0.3
	Oil and Grease	no real trend	3.1	no data collected	-	followed flow	4.6	no real trend	2.6	no real trend	1.7
	Comments	Rain began 01:00. Sampling began 08:00. Sampling largest portion of hydrograph.		Runoff began ≈03:00. Sampling began 08:00. "Tail end" of storm.		Continuation of earlier storm.		Continuation of earlier storm.		Small runoff recorded. Sampling covered most of storm.	

TABLE 20 (CONT'D)

	Date	May 18, 1981		May 24/25, 1981		June 3, 1981		June 18, 1981		June 30, 1981	
	Sample	18:55 - 06:55		21:15 - 08:15		13:00 - 14:30		07:00 - 08:30		07:30 - 10:30	
TRENDS OF CONCENTRATIONS	Constituent	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value
	Suspended Solids	followed flow	40	no real trend	69	followed flow	12.1	followed flow	10	followed flow	40
	Metals: Aluminum	followed flow	0.5	no real trend	1.3	followed flow	2.8	followed flow	0.18	followed flow	1.12
	Copper	followed flow	0.5	no real trend	0.05	followed flow	0.04	no real trend	0.028	followed flow	0.04
	Lead	followed flow	0.1	no real trend	0.1	followed flow	0.2	followed flow	0.023	followed flow	0.09
	Zinc	followed flow	0.25	no real trend	0.35	followed flow	≈0.10	followed flow	0.13	followed flow	0.11
	COD	followed flow	30	no real trend	26	followed flow	81	followed flow	25.5	followed flow	70
	TOC	followed flow	10	no real trend	8	followed flow	35	no real trend	7	followed flow	26
	Total Coliform	no data collected	-	no data collected	-	no data collected	-	followed flow	>24000	no data collected	-
	Fecal Coliform	no data collected	-	no data collected	-	no data collected	-	followed flow	9000	no data collected	-
	Nitrogen - Total	no real trend	2.0	no real trend	2.0	no real trend	3.0	no real trend	1.4	followed flow	3
	- Organic	no real trend	2.0	no real trend	1.1	no real trend	2.0	no real trend	1	followed flow	2
	- Ammonia	no real trend	0.5	no real trend	0.3	no real trend	0.4	no real trend	0.1	followed flow	0.38
	- NO_2/NO_3	no real trend	0.7	no real trend	0.6	no real trend	0.6	no real trend	0.28	followed flow	0.74
	Oil and Grease	no real trend	2.0	no real trend	2.7	followed flow	3.8	followed flow	2.4	followed flow	3.9
	Comments	Runoff from 17:00 to about midnight. Sampling used large time intervals to cover storm.		Runoff from 20:45 to 04:15. Sampling used large time intervals to cover storm.		Runoff from 13:45 to 19:30. Sampling covered first part of storm.		Runoff lasted approximately 16 hours. Sampled in second 1 1/2 hours of storm.		Sampling covered entire runoff period. Almost two complete storms, from 08:00-09:00 and 09:00-10:30.	

TABLE 20 (CONT'D)

	Date	July 6, 1981		August 20, 1981		August 25, 1981		August 31, 1981		September 21, 1981	
	Sample	20:30 - 22:30		06:30 - 08:00		06:00 - 09:00		10:00 - 13:00		16:45 - 18:15	
	Constituent	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value
TRENDS OF CONCENTRATIONS	Suspended Solids	followed flow	39	followed flow	21	followed flow	342	followed flow	48	followed flow	69
	Metals: Aluminum	followed flow	2.1	followed flow	0.39	followed flow	15	followed flow	1.65	followed flow	0.82
	Copper	no real trend	0.08	no real trend	0.07	followed flow	0.35	no real trend	0.22	no real trend	0.03
	Lead	no real trend	0.15	no real trend	0.09	followed flow	1.7	followed flow	0.25	followed flow	0.18
	Zinc	followed flow	0.2	no real trend	0.44	followed flow	1.58	followed flow	0.18	followed flow	0.15
	COD	no real trend	39	followed flow	59	followed flow	270	followed flow	110	followed flow	53
	TOC	no real trend	11	no real trend	23.5	followed flow	58	followed flow	30	followed flow	18
	Total Coliform	no data collected	-	followed flow	>24000	no data collected	-	no real trend	>24000	followed flow	>24000
	Fecal Coliform	no data collected	-	followed flow	9000	no data collected	-	followed flow	>24000	followed flow	16000
	Nitrogen - Total	followed flow	2.2	no real trend	4	followed flow	5	followed flow	5	followed flow	3
	- Organic	no real trend	1.15	no real trend	2	followed flow	4	followed flow	3	followed flow	3
	- Ammonia	no real trend	0.15	no real trend	0.6	followed flow	0.4	followed flow	0.7	no real trend	0.14
	- NO_2/NO_3	followed flow	1	no real trend	1.55	followed flow	1.1	followed flow	1.1	no real trend	0.37
	Oil and Grease	followed flow	3	followed flow	3.1	followed flow	27.6	followed flow	3.5	followed flow	5.5
	Comments	Large runoff lasting from 19:00 to July 7, 07:30. First peak from 19:00 to 20:00. Sampling covered beginning of second major peak.		Large runoff lasting from 03:30 to 09:00. First peak from 03:30 to 05:15. Sampling occurred in middle of second segment.		Runoff lasted from 05:00 to 10:00. Sampling occurred in middle of storm.		Majority of runoff from 15:00 to 19:00. Sampling caught initial runoff period.		Smaller runoff period from 17:00 to 20:00. Sampling caught initial runoff period.	

TABLE 20 (CONT'D)

	Date	September 28, 1981		September 30, 1981		October 1, 1981		October 26, 1981		November 11, 1981	
	Sample	06:00 - 09:00		05:30 - 07:00		09:30 - 12:30		14:15 - 17:15		04:45 - 06:15	
TRENDS OF CONCENTRATIONS	Constituent	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value	Trend	Max Value
	Suspended Solids	followed flow	4	followed flow	3	followed flow	8	no real trend	92	no real trend	17
	Metals: Aluminum	no real trend	0.19	followed flow	0.12	followed flow	0.11	followed flow	0.64	no real trend	0.32
	Copper	no real trend	0.02	followed flow	0.019	followed flow	0.02	followed flow	0.05	no real trend	0.02
	Lead	no real trend	0.018	no real trend	0.015	followed flow	0.032	followed flow	0.19	no real trend	0.05
	Zinc	no real trend	0.27	followed flow	0.22	followed flow	0.11	followed flow	0.14	no real trend	0.08
	COD	no real trend	16	no real trend	13.5	no real trend	17	followed flow	306	followed flow	35
	TOC	no real trend	4	constant value	4	no real trend	5	followed flow	92	followed flow	10
	Total Coliform	no real trend	>24000	no data collected	-	no data collected	-	followed flow	>24000	no data collected	-
	Fecal Coliform	no real trend	16000	no data collected	-	no data collected	-	followed flow	3500	no data collected	-
	Nitrogen - Total	no real trend	0.84	no real trend	1.04	followed flow	3	no real trend	3	no real trend	2.1
	- Organic	no real trend	0.42	no real trend	0.6	followed flow	3	no real trend	2	no real trend	1.6
	- Ammonia	no real trend	0.08	no real trend	0.05	no real trend	0.076	no real trend	0.19	no real trend	0.005
	- NO_2/NO_3	no real trend	0.32	no real trend	0.4	no real trend	0.75	no real trend	0.69	no real trend	0.21
	Oil and Grease	no real trend	1.4	followed flow	2.2	no real trend	1.3	no real trend	4.5	no data collected	-
	Comments	Runoff from 02:00 to 09:00. Sampling caught last half of runoff.		Runoff from 01:00 to 09:00. Sampling caught last part of storm.		Runoff from 03:00 to 23:00.		Runoff from 14:15 to 19:00. Sampling caught first portion of runoff.		Runoff from 03:30 to 11:00. Sampling caught middle of storm.	

TABLE 20 (CONT'D)

TRENDS OF CONCENTRATIONS	Date	November 15, 1981		November 30, 1981	
	Sample	14:00 - 17:00		12:15 - 13:45	
	Constituent	Trend	Max Value	Trend	Max Value
	Suspended Solids	followed flow	26	followed flow	20
	Metals: Aluminum	followed flow	0.54	followed flow	0.48
	Copper	followed flow	0.02	followed flow	0.02
	Lead	followed flow	0.125	no real trend	0.75
	Zinc	followed flow	0.09	followed flow	0.18
	COD	no real trend	740	followed flow	17.5
	TOC	no real trend	220	followed flow	8.5
	Total Coliform	no real trend	>24000	no real trend	16000
	Fecal Coliform	no real trend	2400	no real trend	1800
	Nitrogen - Total	no real trend	1.55	no real trend	0.78
	- Organic	no real trend	0.85	no real trend	0.50
	- Ammonia	no real trend	0.25	no real trend	0.06
	- NO_2/NO_3	no real trend	0.5	no real trend	0.31
	Oil and Grease	followed flow	3.2	no real trend	2.1
	Comments	Runoff from 13:30 to around 24:00. Sampling caught majority of flow from storm.		Huge storm! Runoff from 08:30 for about 24 hours.	

TABLE 21

FACTORS AFFECTING RUNOFF COEFFICIENTS

Date	Runoff Coefficient	Antecedent Dry Weather (hrs)	Average Intensity (mm/hr)	Storm Duration (hrs)	Maximum Hourly Precipitation (mm)
81/01/09	0.39	229	3.50	1	3.5
81/01/09	0.46	4	1.50	1	1.5
81/01/17	0.08	182	0.50	3	0.5
81/01/18	0.22	11	0.90	4	1.0
81/01/18	0.50	1	1.50	3	2.0
81/01/27	0.35	69	1.90	4	2.5
81/01/28	0.22	2	0.50	1	0.5
81/01/28	0.68	2	0.50	2	0.5
81/01/29	0.40	19	0.94	8	1.5
81/02/12	0.25	8	0.50	3	1.0
81/02/12	0.27	1	0.99	12	3.0
81/02/12	0.12	1	0.50	1	0.5
81/02/13	0.06	2	0.50	5	0.5
81/02/13	0.27	1	1.20	7	2.0
81/02/14	0.33	6	1.60	7	3.5
81/02/15	0.32	18	1.50	4	3.5
81/02/15	0.41	2	2.05	10	4.5
81/02/16	0.68	7	1.12	8	2.5
82/02/16	0.60	4	0.91	6	1.5
81/02/17	0.82	7	1.00	1	1.0
81/02/18	0.63	15	2.15	10	8.0
81/02/19	0.62	17	1.50	9	4.5
81/02/26	0.39	15	0.70	5	1.0
81/03/02	0.43	107	1.81	16	4.0
81/03/22	0.60	145	1.17	3	2.5
81/03/23	0.12	24	0.80	5	1.0
81/03/24	0.43	38	2.50	6	3.5
81/03/28	0.44	80	1.84	19	3.0
81/03/29	0.53	5	1.22	9	2.0
81/03/30	0.76	10	1.22	25	3.5
81/04/01	0.20	26	1.0	1	1.0
81/04/02	0.94	22	0.67	3	1.0
81/04/02	0.34	5	0.5	5	0.5
81/04/04	0.71	3	1.60	10	3.0
81/04/08	0.40	9	1.35	13	3.0
81/04/10	0.13	16	0.50	2	0.5
81/04/10	0.20	1	0.50	4	0.5
81/04/12	0.40	23	2.05	10	6.0
81/04/20	0.30	195	1.20	6	1.5
81/04/21	0.35	3	0.86	11	2.0
81/04/22	0.64	1	1.45	29	3.5
81/04/27	0.53	88	1.06	25	3.0

TABLE 21 (CONT'D)

Date	Runoff Coefficient	Antecedent Dry Weather (hrs)	Average Intensity (mm/hr)	Storm Duration (hrs)	Maximum Hourly Precipitation (mm)
81/04/30	0.39	28	1.50	1	1.5
81/05/01	0.06	26	0.50	1	0.5
81/05/02	0.26	5	0.70	5	1.0
81/05/02	0.18	18	0.50	1	0.5
81/05/03	0.51	8	1.57	20	7.0
81/05/06	0.26	40	0.50	5	0.5
81/05/10	0.19	40	1.25	2	2.0
81/05/13	0.20	60	0.50	2	0.5
81/05/14	0.27	16	1.14	7	1.5
81/05/15	0.40	14	1.17	3	2.0
81/05/17	0.18	58	0.75	2	1.0
81/05/18	0.27	20	1.29	7	4.5
81/05/21	0.13	3	0.50	2	0.5
81/05/24	0.16	4	1.00	1	1.0
81/05/24	0.24	2	1.50	1	1.5
81/05/24	0.34	5	2.44	8	8.0
81/05/29	0.68	108	0.75	2	1.0
81/05/29	0.21	2	1.25	2	2.0
81/05/29	0.14	2	0.75	2	1.0
81/05/30	0.09	20	1.00	2	1.5
81/06/02	0.14	68	1.00	4	1.5
81/06/03	0.06	4	1.00	1	1.0
81/06/03	0.15	1	0.75	4	1.0
81/06/04	0.14	20	1.00	2	1.0
81/06/09	0.15	16	3.83	3	9.5
81/06/10	0.37	6	1.88	4	4.0
81/06/10	0.20	5	1.25	2	2.0
81/06/12	0.36	43	4.00	2	5.0
81/06/13	0.49	11	1.40	12	3.5
81/06/15	0.39	51	1.10	5	2.0
81/06/17	0.18	48	0.50	2	0.5
81/06/18	0.45	5	1.70	15	4.0
81/06/19	0.23	27	0.75	2	1.0
81/06/21	0.18	33	0.88	4	1.5
81/06/21	0.08	7	1.00	1	1.0
81/06/21	0.17	1	0.67	3	1.0
81/06/22	0.37	3	1.25	2	2.0
81/06/23	0.42	23	1.88	4	2.5
81/06/28	0.13	138	1.00	4	2.5
81/06/29	0.18	1	1.25	2	1.5
81/07/05	0.07	140	0.50	1	0.5
81/07/06	0.33	25	4.39	9	23.0
81/07/07	0.15	13	1.00	1	1.0
81/07/10	0.07	10	0.75	3	0.5
81/07/13	0.28	69	0.50	1	0.5
81/08/20	0.34	556	3.00	6	7.5
81/08/25	0.35	115	2.50	6	5.5
81/08/31	0.31	57	1.86	11	5.0

TABLE 21 (CONT'D)

Date	Runoff Coefficient	Antecedent Dry Weather (hrs)	Average Intensity (mm/hr)	Storm Duration (hrs)	Maximum Hourly Precipitation (mm)
81/09/01	0.41	4	1.25	2	2.0
81/09/20	0.04	264	0.50	1	0.5
81/09/20	0.29	1	3.63	4	8.5
81/09/21	0.39	1	1.13	4	2.5
81/09/21	0.29	9	1.50	4	2.5
81/09/21	0.03	3	0.50	1	0.5
81/09/22	0.36	1	1.50	4	2.0
81/09/27	0.53	2	1.17	3	2.0
81/09/27	0.21	2	0.75	3	0.5
81/09/27	0.45	2	1.19	8	2.5
81/09/28	0.39	2	1.25	8	3.5
81/09/28	0.65	4	0.50	1	0.5
81/09/30	0.44	36	1.17	9	2.0
81/10/01	0.92	15	2.50	14	5.0
81/10/02	0.47	22	0.50	2	0.5
81/10/05	0.40	62	1.07	14	3.0
81/10/06	0.32	2	1.75	2	2.5
81/10/06	0.54	10	1.33	9	4.0
81/10/07	0.91	6	1.25	4	1.0
81/10/07	0.57	8	0.80	5	1.5
81/10/08	0.83	4	0.50	3	0.5
81/10/08	0.75	7	2.33	6	4.0
81/10/09	0.93	3	1.00	6	1.5
81/10/26	0.35	411	1.00	4	1.0
81/10/26	0.45	4	0.75	2	1.0
81/10/27	0.57	3	1.38	8	3.0
81/10/28	0.55	10	1.17	6	2.5
81/10/28	0.40	3	1.50	1	1.5
81/10/28	0.50	1	1.50	1	1.5
81/10/28	0.57	6	0.50	1	0.5
81/10/30	0.84	36	2.32	38	8.0
81/11/10	0.64	281	0.50	1	0.5
81/11/11	0.62	2	1.33	23	4.5
81/11/13	0.67	15	1.17	3	2.5
81/11/13	0.62	13	1.00	5	2.0
81/11/14	0.66	5	1.30	5	3.5
81/11/15	0.75	22	1.67	6	4.0
81/11/17	0.70	17	1.24	19	2.5
81/11/19	0.78	26	2.08	6	4.5

TABLE 21 (CONT'D)

Date	Runoff Coefficient	Antecedent Dry Weather (hrs)	Average Intensity (mm/hr)	Storm Duration (hrs)	Maximum Hourly Precipitation (mm)
81/11/20	0.65	25	1.70	5	3.5
81/11/21	0.94	1	1.04	24	3.0
81/11/24	0.54	8	2.38	4	7.0
81/11/25	0.76	22	1.21	12	2.5
81/11/29	0.32	81	0.88	4	1.0
81/11/29	0.24	11	1.00	1	1.0
81/11/30	0.81	12	2.45	28	6.5
81/12/08	0.64	35	1.00	2	1.5
81/12/09	0.67	43	1.02	26	3.0
81/12/13	0.54	72	1.07	7	1.5

TABLE 22

COMPARISON OF MEAN STORMWATER CONCENTRATIONS AND MEAN MINICIPAL SEWAGE TREATMENT PLANT CONCENTRATIONS

Parameter	VALUES*					Annacis STP Ratio Max:Min
	This Study		Ferguson and Hall(3)	Ontario(19)	Annacis STP Effluent 1979(27)	
	Mean**	Flow-Weighted*** Mean				
BOD_5	<10	-	29	14	157	2.79:1
Coliform - Total	9200+	-	100 000	-	-	-
- Fecal	2400+	-	11 000	-	-	-
COD	33.2	24.6	-	-	321	3.82:1
Metals: Copper	0.037	0.038	0.01	-	0.06++	3.5:1
Iron	0.918	-	0.255	-	0.74++	9.23:1
Lead	0.071	0.059	0.06	-	0.03	5.1:1
Manganese	0.04	-	0.023	-	-	-
Nickel	<0.05	-	0.002	-	<0.05++	3.6:1
Zinc	0.12	0.123	0.008	-	0.16	2.2:1
Nitrogen - Total	1.61	1.55	2	3.5	24	2.58:1
Phosphorus - Total	0.089	0.161	0.6	0.35	4.4	2.75:1
Solids - Suspended	19.8	22.8	-	170	74	8.06:1

* Values are as mg/L except Coliform as MPN/100 mL.
** From Table 11
*** From Table 13
+ Median
++ Dissolved

TABLE 23

FIRST HOUR LOADINGS (kg/hr) FROM ALL CATCHMENT AREAS[a]

Date	First Hour Load - All Residential Areas[a]								
	Suspended Solids	COD	TOC	Aluminum	Lead	Copper	Zinc	Total Nitrogen	Total Phosphorus
81/01/20[b]	858	1512	368	18.1	3.86	0.68	3.0	59.1	4.1
81/02/12	1701	955	366	16.8	2.04	0.82	5.04	75.2	86.1
81/02/17	418	553	245	7.3	1.29	1.29	1.94	50.4	2.2
81/02/18	601	788	213	14.3	3.45	1.97	3.12	119	3.1
81/03/24	3426	4310	1127	56.8	12.04	5.00	12.72	186.5	14.3
81/04/29	371	712	176	3.4	0.82	0.95	2.59	51.4	3.1
81/06/08	2919	2528	973	57.8	7.40	1.04	3.91	63.6	10.2
81/06/30	2422	4247	1504	47.7	7.36	1.36	7.08	186.2	13.2
81/08/31	1208	2985	855	38.1	5.58	2.86	4.63	128.9	9.8
81/09/21	5047	5739	1671	83.1	17.98	3.81	18.66	288.5	6.8
81/10/26	2183	11833	3679	35.4	9.81	2.72	7.90	120.1	2.5
81/11/15[b]	1665	22586	7058	41	10.34	1.64	6.90	110.7	19.5
Mean Residential Areas	1902	4896	152	35	6.83	2.01	6.46	120	14.6
Mean[c] All Areas	-	7640	-	-	10.09	7.42	35.24	230	20.8
Municipal STP[d] 1/24 Avg. Load	1667	5917	-	26	1.15	1.69[e]	3.93	580	97.1
Municipal STP[f] Peak Load	5000	17750	-	78	3.45	5.07	11.8	1740	291.3

(a) Loadings extrapolated using residential area of 17640 ha, calculated by Ferguson and Hall[3] as draining to the Fraser River.

(b) Data available for only part of first hour of storm - data for entire first hour has been extrapolated using flows and flow averaged concentrations determined from the period of the storm monitored.

(c) Loadings for all areas use the ratios determined by Ferguson and Hall[3] between total loading for that parameter for residential and all areas.

(d) From Cain and Swain[27], using data for 1979 (Iona + Annacis + Lulu)

(e) Dissolved.

(f) Peak load calculated by using a factor of 3:1 relative to the average load.

TABLE 24

CONTAMINANT LOADINGS (kg/d) FROM RUPERT AND ROSEMONT EXTRAPOLATED TO ALL RESIDENTIAL AREAS IN THE FRASER RIVER ESTUARY STUDY AREA

	Dry Weather		Wet Weather		Balance[+] from Wet Weather Rupert and Rosemont	Loading[++] From All Residential Areas
COD	12.0*	7.39[+]	63.21**	8.55[+]	1.16	1580
Metals:						
Aluminum	0.108*	0.07[+]	1.21**	0.17[+]	0.10	136
Copper	0.007*	0.004[+]	0.071**	0.013[+]	0.009	12.3
Lead	0.007*	0.004[+]	0.164**	0.021[+]	0.017	23.2
Zinc	0.017*	0.010[+]	0.26**	0.043[+]	0.033	45
Nitrogen: Total	0.46*	0.28[+]	3.15**	0.54[+]	0.26	354
Phosphorus: Total	0.03*	0.019[+]	0.396*	0.056[+]	0.037	50.4
Solids: Suspended	4.59*	2.82[+]	44.47**	7.94[+]	5.12	6974
TOC	3.60*	2.21[+]	19.07**	2.62[+]	0.41	558

* From Table 12 (mean daily load).

** From Table 13 (mean daily load).

[+] Flow-weighted concentration times average daily flow (flows from Appendix 1).

[++] Ferguson and Hall(3) claimed 17640 ha of residential area within the Fraser River Estuary study area. Using this land area and extrapolating the loading for 12.95 ha (defined as "balance from wet weather"), the figures in this column were obtained.

TABLE 25

DETERMINATION OF FIRST FLUSH* EVENTS

Date/ Comments	Flow (m³)		LOADING (kg)												
			Suspended Solids			COD			TOC			Aluminum		
	Incremental⁺	I/T⁺⁺	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**
81/01/20	13.9		RUNOFF STARTED AT 20:00											
21:00-21:15	8.6	0.030	0.232	0.036	1.20:1	0.370	0.053	1.77:1	0.095	0.045	1.5:1	0.005	0.037	1.23:1
21:15-21:30	7.7	0.027	0.146	0.023	<1:1	0.293	0.042	1.56:1	0.069	0.032	1.19:1	0.003	0.022	<1:1
21:30-21:45	7.0	0.025	0.105	0.016	<1:1	0.210	0.030	1.2:1	0.042	0.020	<1:1	0.003	0.022	<1:1
21:45-22:00	6.6	0.023	0.086	0.013	<1:1	0.165	0.024	1.04:1	0.040	0.019	<1:1	0.002	0.014	<1:1
22:00-22:15	8.1	0.029	0.146	0.023	<1:1	0.243	0.035	1.21:1	0.057	0.027	<1:1	0.003	0.022	<1:1
22:15-22:30	17.4	0.062	0.696	0.108	1.74:1	0.592	0.085	1.37:1	0.209	0.098	1.58:1	0.013	0.096	1.55:1
TOTAL⁺⁺	282.4	-	5.447	-	-	6.936	-	-	2.124	-	-	0.136	-	-
81/01/28														
07:00-07:15	2.6	0.029	0.120	0.059	2.03:1	0.131	0.060	2.07:1	0.049	0.074	2.55:1	0.002	0.048	1.66:1
07:15-07:45	13.4	0.151	0.710	0.351	2.32:1	0.619	0.285	1.39:1	0.161	0.242	1.60:1	0.008	0.190	1.26:1
07:45-08:05	14.3	0.167	0.503	0.249	1.49:1	0.622	0.286	1.71:1	0.163	0.245	1.47:1	0.005	0.119	<1:1
08:05-08:30	16	0.181	0.544	0.269	1.49:1	0.529	0.243	1.24:1	0.160	0.240	1.33:1	0.017	0.404	2.23:1
TOTAL⁺⁺	88.5	-	2.029	-	-	2.171	-	-	0.666	-	-	0.042	-	-
81/02/12														
03:00-08:15	1.1	0.022	0.138	0.122	5.55:1	0.057	0.047	2.14:1	0.018	0.048	2.18:1	0.001	0.042	1.91:1
08:15-08:30	1.1	0.022	0.129	0.114	5.18:1	0.052	0.043	1.95:1	0.018	0.048	2.18:1	0.001	0.042	1.91:1
08:30-09:00	7.6	0.153	0.306	0.710	4.64:1	0.327	0.268	1.75:1	0.129	0.345	2.25:1	0.007	0.292	1.91:1
09:00-09:30	10.8	0.217	0.443	0.390	1.30:1	0.374	0.306	1.41:1	0.140	0.374	1.72:1	0.005	0.208	<1:1
TOTAL⁺⁺	49.7	-	1.135	-	-	1.221	-	-	0.374	-	-	0.024	-	-
81/02/17														
15:30-15:45	1.2	0.0007	0.002	0.0001	<1:1	<0.012	-	-	0.006	0.0005	<1:1	0.000	-	-
15:45-16:00	1.2	0.0007	0.004	0.0001	<1:1	<0.012	-	-	0.006	0.0005	<1:1	0.000	-	-
16:00-16:15	1.2	0.0007	0.008	0.0002	<1:1	0.020	0.0005	<1:1	0.007	0.0006	<1:1	0.000	-	-
16:15-16:30	2.7	0.0016	0.041	0.0011	<1:1	0.046	0.0011	<1:1	0.019	0.0015	<1:1	0.001	0.0012	<1:1
16:30-16:45	7.2	0.0043	0.065	0.0017	<1:1	0.122	0.0030	<1:1	0.050	0.0040	<1:1	0.002	0.0025	<1:1
16:45-17:00	7.5	0.0045	0.090	0.0024	<1:1	0.090	0.0022	<1:1	0.045	0.0036	<1:1	0.001	0.0012	<1:1
TOTAL	1676.3	-	38.27	-	-	41.17	-	-	12.61	-	-	0.805	-	-

TABLE 25 (Continued)

DETERMINATION OF FIRST FLUSH* EVENTS

Date/ Comments	LOADING (kg)														
	Lead			Copper			Zinc			Total Nitrogen			Total Phosphorus		
	Incremental+	I/T++	Ratio**	Incremental+	I/T++	Ratio**	Incremental+	I/T++	Ratio**	Incremental+	I/T++	Ratio**	Incremental+	I/T++	Ratio**
81/01/20	0.0010	0.060	2.0:1	0.0002	0.019	<1:1	0.0003	0.023	<1:1	0.0090	0.021	<1:1	0.0010	0.022	<1:1
21:00-21:15	0.0007	0.042	1.56:1	0.0001	0.008	<1:1	0.0005	0.014	<1:1	0.0170	0.039	1.44:1	0.0008	0.018	<1:1
21:15-21:30	0.0005	0.030	1.2:1	0.0001	0.008	<1:1	0.0004	0.012	<1:1	0.0040	0.009	<1:1	0.0005	0.011	<1:1
21:30-21:45	0.0004	0.024	1.04:1	0.0001	0.003	<1:1	0.0003	0.009	<1:1	0.0040	0.009	<1:1	0.0004	0.009	<1:1
21:45-22:00	0.0005	0.030	1.03:1	0.0007	0.065	2.24:1	0.0004	0.012	<1:1	0.0120	0.027	<1:1	0.0007	0.015	<1:1
22:00-22:15	0.0022	0.132	2.13:1	0.0003	0.028	<1:1	0.0016	0.046	<1:1	0.0300	0.069	1.11:1	0.0021	0.046	<1:1
22:15-22:30	0.0167	-	-	0.0107	-	-	0.0347	-	-	0.4377	-	-	0.0455	-	-
TOTAL++															
81/01/28	0.0002	0.038	1.31:1	0.0001	0.009	<1:1	0.0004	0.011	<1:1	0.0080	0.018	<1:1	0.0010	0.022	<1:1
07:00-07:15	0.0013	0.250	1.66:1	0.0003	0.028	<1:1	0.0015	0.043	<1:1	0.0270	0.061	<1:1	0.0050	0.108	<1:1
07:15-07:45	0.0008	0.154	<1:1	0.0002	0.018	<1:1	0.0010	0.028	<1:1	0.0300	0.068	<1:1	0.0040	0.087	<1:1
07:45-08:05	0.0032	0.615	3.40:1	0.0005	0.046	<1:1	0.0019	0.054	<1:1	0.0160	0.036	<1:1	0.0040	0.087	<1:1
08:05-08:30	0.0052	-	-	0.0109	-	-	0.0352	-	-	0.4440	-	-	0.0461	-	-
TOTAL++															
81/02/12	0.0001	0.034	1.55:1	0.0000	0	<1:1	0.0002	0.033	1.5:1	0.0033	0.043	1.95:1	0.0005	ACTUAL TOTAL GREATER THAN THEORETICAL	
08:00-08:15	0.0002	0.069	3.14:1	0.0000	0	<1:1	0.0002	0.033	1.5:1	0.0033	0.043	1.95:1	0.0005		
08:15-08:30	0.0007	0.241	1.58:1	0.0001	0.053	<1:1	0.0016	0.262	1.71:1	0.0228	0.296	1.93:1	0.0616		
08:30-09:00	0.0008	0.276	1.27:1	0.0005	0.263	1.21:1	0.0021	0.344	1.59:1	0.0324	0.421	1.94:1	0.0016		
09:00-09:30	0.0029	-	-	0.0019	-	-	0.0061	-	-	0.0770	-	-	0.0080		
TOTAL++															
81/02/17	0.0000	-	-	0.0000	-	-	0.0000	-	-	0.0027	0.0010	1.43:1	0.0000	-	-
15:30-15:45	0.0000	-	-	0.0000	-	-	0.0001	0.0005	<1:1	0.0025	0.0010	1.43:1	0.0000	-	-
15:45-16:00	0.0000	-	-	0.0000	-	-	0.0001	0.0005	<1:1	0.0022	0.0008	1.14:1	0.0000	-	-
16:00-16:15	0.0001	0.0010	<1:1	0.0000	-	-	0.0001	0.0005	<1:1	0.0040	0.0015	<1:1	0.0002	0.0007	<1:1
16:15-16:30	0.0003	0.0030	<1:1	0.0004	0.0063	1.47:1	0.0004	0.0019	<1:1	0.0096	0.0037	<1:1	0.0004	0.0015	<1:1
16:30-16:45	0.0002	0.0020	<1:1	0.0002	0.0031	<1:1	0.0004	0.0019	<1:1	0.0098	0.0038	<1:1	0.0004	0.0015	<1:1
16:45-17:00	0.0989	-	-	0.0637	-	-	0.2062	-	-	2.5983	-	-	0.2699	-	-
TOTAL															

TABLE 25 (Continued)

Date/ Comments	Flow (m³)		LOADING (kg)														
			Suspended Solids			COD			TOC			Aluminum		
	Incremental⁺	I/T⁺⁺	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**
81/02/18														
19:00-19:15	14	0.0128	0.154	0.0062	<1:1	0.238	0.0089	<1:1	0.070	0.0085	<1:1	0.004	0.0076	<1:1
19:15-19:30	10.1	0.0092	0.111	0.0044	<1:1	0.121	0.0045	<1:1	0.030	0.0036	<1:1	0.003	0.0057	<1:1
19:30-19:45	10.1	0.0092	0.101	0.0040	<1:1	0.121	0.0045	<1:1	0.030	0.0036	<1:1	0.002	0.0038	<1:1
19:45-20:00	12.3	0.0117	0.166	0.0067	<1:1	0.154	0.0057	<1:1	0.051	0.0062	<1:1	0.004	0.0076	<1:1
20:00-20:15	18.6	0.0170	0.136	0.0075	<1:1	<0.186	-	-	0.037	0.0045	<1:1	0.004	0.0076	<1:1
20:15-20:30	23.3	0.0218	0.238	0.0095	<1:1	<0.238	-	-	0.071	0.0086	<1:1	0.003	0.0057	<1:1
TOTAL	1093.5	-	24.96	-	-	25.36	-	-	3.223	-	-	0.525	-	-
81/03/24	38.5		RUNOFF STARTED AT 22:00											
22:45-23:00	26.1	0.034	0.940	0.053	1.56:1	0.940	0.049	1.44:1	0.237	0.049	1.44:1	0.012	0.032	<1:1
23:00-23:15	29.9	0.039	0.568	0.032	<1:1	0.957	0.050	1.23:1	0.209	0.036	<1:1	0.014	0.038	<1:1
23:15-23:30	32.7	0.042	0.523	0.030	<1:1	0.654	0.034	<1:1	0.164	0.028	<1:1	0.010	0.027	<1:1
23:30-23:45	42.3	0.055	1.734	0.098	1.78:1	1.210	0.064	1.16:1	0.169	0.029	<1:1	0.019	0.051	<1:1
23:45-24:00	44.4	0.057	0.400	0.023	<1:1	<0.444	-	-	0.311	0.053	<1:1	0.007	0.019	<1:1
24:00-00:15	40.3	0.053	0.286	0.016	<1:1	0.498	0.026	<1:1	0.163	0.028	<1:1	0.006	0.016	<1:1
TOTAL	775	-	17.69	-	-	19.03	-	-	5.823	-	-	0.372	-	-
81/04/29			SMALL RUNOFF											
10:00-10:15	6.9	0.124	0.090	0.071	<1:1	0.173	0.127	1.02:1	0.035	0.084	<1:1	0.001	0.037	<1:1
10:15-10:30	6.3	0.114	0.075	0.060	<1:1	0.158	0.116	1.02:1	0.033	0.091	<1:1	0.001	0.037	<1:1
10:30-10:45	4.1	0.074	0.053	0.042	<1:1	0.082	0.060	<1:1	0.029	0.070	<1:1	0.000	-	<1:1
10:45-11:00	3.3	0.068	0.053	0.042	<1:1	0.110	0.081	1.19:1	0.027	0.065	<1:1	0.001	0.037	<1:1
11:00-11:15	6.2	0.112	0.056	0.044	<1:1	0.155	0.114	1.02:1	0.037	0.089	<1:1	0.001	0.037	<1:1
11:15-11:30	6.4	0.115	0.120	0.095	<1:1	0.160	0.117	1.02:1	0.045	0.108	<1:1	0.001	0.037	<1:1
TOTAL	55.5	-	1.267	-	-	1.363	-	-	0.417	-	-	0.027	-	-
81/06/08														
13:00-13:15	0.7	0.002	0.052	0.006	3:1	0.057	0.006	3:1	0.020	0.007	3.5:1	0.001	0.006	3:1
13:15-13:30	0.7	0.002	0.046	0.006	3:1	0.057	0.006	3:1	0.022	0.008	4.1:1	0.001	0.006	3:1
13:30-13:45	2.3	0.006	0.076	0.009	1.5:1	0.108	0.012	2:1	0.046	0.017	2.83:1	0.002	0.012	2:1
13:45-14:00	9.7	0.027	1.174	0.143	5.3:1	0.737	0.083	3.07:1	0.330	0.122	4.52:1	0.028	0.162	6:1
14:00-14:15	11.7	0.033	0.527	0.064	1.94:1	0.445	0.050	1.52:1	0.105	0.039	1.18:1	0.009	0.052	1.58:1
14:15-14:30	33.3	0.093	0.366	0.045	<1:1	0.566	0.064	<1:1	0.233	0.086	<1:1	0.004	0.023	<1:1
TOTAL	359.6		8.210			8.832			2.704			0.173		

TABLE 25 (Continued)

Date/ Comments	LOADING (kg)														
	Lead			Copper			Zinc			Total Nitrogen			Total Phosphorus		
	Incremental+	I/T++	Ratio**	Incremental+	I/T++	Ratio**	Incremental+	I/T++	Ratio**	Incremental+	I/T++	Ratio**	Incremental+	I/T++	Ratio**
81/02/13	0.0006	0.0144	1.13:1	0.0002	0.0075	<1:1	0.0006	0.0069	<1:1	0.0344	0.0315	2.46:1	0.0008	0.0071	<1:1
19:00-19:15	0.0012	0.0288	3.13:1	0.0007	0.0261	2.34:1	0.0009	0.0104	1.13:1	0.0246	0.0225	2.45:1	0.0006	0.0053	<1:1
19:15-19:30	0.0003	0.0072	1.03:1	0.0003	0.0112	1.22:1	0.0004	0.0046	<1:1	0.0135	0.0124	1.35:1	0.0005	0.0044	<1:1
19:30-19:45	0.0005	0.0120	1.03:1	0.0004	0.0149	1.27:1	0.0004	0.0046	<1:1	0.0142	0.0130	1.11:1	0.0006	0.0053	<1:1
19:45-20:00	0.0005	0.0120	<1:1	0.0004	0.0149	<1:1	0.0007	0.0081	<1:1	0.0201	0.0134	1.08:1	0.0007	0.0062	<1:1
20:00-20:15	0.0006	0.0144	<1:1	0.0002	0.0075	<1:1	0.0010	0.0115	<1:1	0.0205	0.0188	<1:1	0.0008	0.0071	<1:1
20:15-20:30	0.0416	-	-	0.0268	-	-	0.0866	-	-	1.092	-	-	0.1134	-	-
TOTAL															
81/03/24															
22:45-23:00	0.0026	0.057	1.68:1	0.0010	0.034	1:1	0.0026	0.027	<1:1	0.0522	0.043	1.26:1	0.0035	0.028	<1:1
23:00-23:15	0.0027	0.059	1.51:1	0.0012	0.041	1.05:1	0.0030	0.031	<1:1	0.0299	0.025	<1:1	0.0028	0.022	<1:1
23:15-23:30	0.0016	0.035	<1:1	0.0016	0.054	1.29:1	0.0049	0.051	1.21:1	0.0738	0.066	1.57:1	0.0039	0.031	<1:1
23:30-23:45	0.0034	0.074	1.35:1	0.0013	0.044	<1:1	0.0042	0.044	<1:1	0.1066	0.089	1.62:1	0.0053	0.042	<1:1
23:45-24:00	0.0013	0.028	<1:1	0.0008	0.027	<1:1	0.0036	0.038	<1:1	0.0431	0.036	<1:1	0.0025	0.020	<1:1
24:00-00:15	0.0007	0.015	<1:1	0.0020	0.068	1.28:1	0.0053	0.056	1.06:1	0.0326	0.027	<1:1	0.0018	0.014	<1:1
TOTAL	0.0457	-	-	0.0295	-	-	0.0953	-	-	1.2013	-	-	0.1248	-	-
81/04/29															
10:00-10:15	0.0002	0.061	<1:1	0.0001	0.048	<1:1	0.0009	0.132	1.06:1	0.0138	0.160	1.29:1	0.0008	0.090	<1:1
10:15-10:30	0.0002	0.061	<1:1	0.0003	0.143	1.25:1	0.0006	0.088	<1:1	0.0095	0.110	<1:1	0.0007	0.079	<1:1
10:30-10:45	0.0001	0.030	<1:1	0.0001	0.048	<1:1	0.0002	0.029	<1:1	0.0068	0.079	1.07:1	0.0003	0.034	<1:1
10:45-11:00	0.0001	0.030	<1:1	0.0002	0.095	1.40:1	0.0002	0.029	<1:1	0.0076	0.088	1.29:1	0.0005	0.056	<1:1
11:00-11:15	0.0002	0.061	<1:1	0.0001	0.048	<1:1	0.0004	0.059	<1:1	0.0091	0.106	<1:1	0.0004	0.045	<1:1
11:15-11:30	0.0003	0.091	<1:1	0.0002	0.095	<1:1	0.0004	0.059	<1:1	0.0111	0.129	1.12:1	0.0006	0.067	<1:1
TOTAL	0.0033	-	-	0.0021	-	-	0.0068	-	-	0.0860	-	-	0.0089	-	-
81/06/08															
13:00-13:15	0.0001	0.005	2.5:1	0.0000	-	-	0.0001	0.002	1:1	0.0021	0.004	2:1	0.0002	0.003	1.5:1
13:15-13:30	0.0001	0.005	2.5:1	0.0000	-	-	0.0001	0.002	1:1	0.0014	0.003	1.5:1	0.0002	0.003	1.5:1
13:30-13:45	0.0002	0.010	1.67:1	0.0000	-	-	0.0002	0.005	<1:1	0.0023	0.004	<1:1	0.0005	0.009	1.5:1
13:45-14:00	0.0014	0.067	2.48:1	0.0004	0.029	1.07:1	0.0009	0.020	<1:1	0.0194	0.035	1.30:1	0.0031	0.053	1.96:1
14:00-14:15	0.0023	0.110	3.33:1	0.0001	0.007	<1:1	0.0008	0.013	<1:1	0.0077	0.014	<1:1	0.0015	0.026	<1:1
14:15-14:30	0.0015	0.071	<1:1	0.0002	0.014	<1:1	0.0010	0.023	<1:1	0.0173	0.031	<1:1	0.0023	0.040	<1:1
TOTAL	0.0210			0.0140			0.0440			0.5570			0.0580		

TABLE 25 (Continued)

Date/ Comments	Flow (m^3)		LOADING (kg)											
			Suspended Solids			COD			TOC			Aluminum		
	Incremental^{+}	I/T^{++}	Incremental^{+}	I/T^{++}	Ratio**	Incremental^{+}	I/T^{++}	Ratio**	Incremental^{+}	I/T^{++}	Ratio**	Incremental^{+}	I/T^{++}	Ratio**
81/06/30														
07:30-07:45	0.5	0.004	0.002	0.001	<1:1	0.000	ACTUAL TOTAL GREATER THAN THEORETICAL		0.001	ACTUAL TOTAL GREATER THAN THEORETICAL		0.000	-	-
07:45-08:00	0.5	0.004	0.001	0.000	<1:1	0.000			0.001			0.000	-	-
08:00-08:15	33.4	0.271	1.403	0.499	1.34:1	2.308			0.368			0.011	0.186	<1:1
08:15-08:30	31.2	0.253	0.339	0.121	<1:1	0.673			0.191			0.024	0.407	<1:1
08:30-08:45	3.4	0.028	0.020	0.007	<1:1	0.069			0.027			0.000	-	-
08:45-09:00	2.6	0.021	0.016	0.006	<1:1	0.063			0.013			0.000	-	-
09:00-09:15	3.8	0.031	0.027	0.010	<1:1	0.108			0.030			0.001	0.017	<1:1
09:15-09:30	8.4	0.068	0.151	0.054	<1:1	0.403			0.143			0.003	0.051	<1:1
09:30-09:45	21	0.171	0.294	0.105	<1:1	0.756			0.231			0.008	0.136	<1:1
09:45-10:00	9.9	0.080	0.069	0.025	<1:1	0.242			0.039			0.002	0.034	<1:1
10:00-10:15	3.5	0.028	0.014	0.005	<1:1	0.056			0.028			0.000	-	-
10:15-10:30	2.9	0.024	0.009	0.003	<1:1	0.046			0.020			0.000	-	-
TOTAL	123.1		2.31			3.023			0.926			0.059		
81/08/31														
10:00-10:15	0.9	0.001	0.002	0.000	<1:1	0.021	0.001	1:1	0.006	0.001	1:1	0.000	-	-
10:15-10:30	6.2	0.007	0.251	0.013	1.86:1	0.632	0.031	4.43:1	0.136	0.030	4.29:1	0.010	0.025	3.57:1
10:30-10:45	12.1	0.015	0.581	0.031	2.07:1	1.331	0.065	4.33:1	0.363	0.058	3.87:1	0.017	0.043	2.37:1
10:45-11:00	2.3	0.003	0.050	0.003	1:1	0.207	0.010	3.33:1	0.073	0.012	4:1	0.001	0.003	1:1
11:00-11:15	1.3	0.002	0.013	0.001	<1:1	0.067	0.003	1.5:1	0.021	0.003	1.5:1	0.000	-	-
11:15-11:30	1.6	0.002	0.006	0.000	<1:1	0.038	0.002	1:1	0.013	0.002	1:1	0.000	-	-
11:30-11:45	1.6	0.002	0.008	0.000	<1:1	0.057	0.003	1.5:1	0.021	0.003	1.5:1	0.000	-	-
11:45-12:00	3.1	0.004	0.034	0.002	<1:1	0.171	0.008	2:1	0.053	0.009	2.25:1	0.001	0.003	<1:1
12:00-12:15	6.3	0.008	0.068	0.004	<1:1	0.347	0.017	2.13:1	0.116	0.019	2.38:1	0.001	0.003	<1:1
12:15-12:30	4	0.005	0.024	0.001	<1:1	0.189	0.009	1.8:1	0.064	0.010	2:1	0.001	0.003	<1:1
12:30-12:45	1.5	0.002	0.009	0.000	<1:1	0.065	0.003	1.5:1	0.021	0.003	1.5:1	0.000	-	-
12:45-13:00	1.1	0.001	0.004	0.000	<1:1	0.035	0.002	2:1	0.012	0.002	2:1	0.000	-	-
18:00-21:00	132.1	0.159	3.170	0.168	1.06:1	3.646	0.179	1.13:1	1.321	0.212	1.33:1	0.0012	0.030	<1:1
21:00-24:00	17.6	0.021	0.140	0.007	<1:1	0.415	0.020	<1:1	0.088	0.014	<1:1	0.002	0.005	<1:1
TOTAL	828.4	-	18.91	-	-	20.35	-	-	6.23	-	-	0.400	-	-

TABLE 25 (Continued)

Date/ Comments	LOADING (kg)														
	Lead			Copper			Zinc			Total Nitrogen			Total Phosphorus		
	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**
81/06/30															
07:30-07:45	0.0000	-	-	0.0000	-	-	0.0000	-	-	0.0004	0.002	<1:1	0.0000	ACTUAL TOTAL GREATER THAN THEORETICAL	
07:45-08:00	0.0000	-	-	0.0000	-	-	0.0000	-	-	0.0003	0.002	<1:1	0.0000		
08:00-08:15	0.0023	0.315	1.16:1	0.0004	0.085	<1:1	0.0027	0.179	<1:1	0.1002	0.525	1.94:1	0.0068		
08:15-08:30	0.0029	0.397	1.57:1	0.0006	0.128	<1:1	0.0023	0.152	<1:1	0.0310	0.162	<1:1	0.0024		
08:30-08:45	0.0001	0.014	<1:1	0.0000	-	-	0.0001	0.007	<1:1	0.0032	0.017	<1:1	0.0003		
08:45-09:00	0.0001	0.014	<1:1	0.0000	-	-	0.0001	0.007	<1:1	0.0023	0.012	<1:1	0.0002		
09:00-09:15	0.0001	0.014	<1:1	0.0000	-	-	0.0002	0.013	<1:1	0.0044	0.023	<1:1	0.0480		
09:15-09:30	0.0005	0.068	14.5:1	0.0002	0.043	<1:1	0.0005	0.033	<1:1	0.0168	0.088	1.29:1	0.0022		
09:30-09:45	0.0013	0.247	>1:1	0.0004	0.085	<1:1	0.0013	0.086	5.06:1	0.0309	0.162	<1:1	0.0035		
09:45-10:00	0.0004	0.055	<1:1	0.0001	0.021	<1:1	0.0006	0.040	<1:1	0.0094	0.049	<1:1	0.0009		
10:00-10:15	0.0001	0.014	<1:1	0.0000	-	-	0.0002	0.013	<1:1	0.0036	0.019	<1:1	0.0002		
10:15-10:30	0.0001	0.014	<1:1	0.0000	-	-	0.0002	0.013	<1:1	0.0020	0.010	<1:1	0.0002		
TOTAL	0.0073			0.0047			0.0151			0.1908			0.0198		
81/03/31															
10:00-10:15	0.0000	-	-	0.0000	-	-	0.0001	0.001	1:1	0.0009	0.001	1:1	0.0000	-	-
10:15-10:30	0.0007	0.014	2:1	0.0014	0.044	6.29:1	0.0011	0.011	1.57:1	0.0243	0.019	2.71:1	0.0013	0.013	1.36:1
10:30-10:45	0.0023	0.057	3.3:1	0.0006	0.019	1.27:1	0.0019	0.019	1.27:1	0.0605	0.047	3.13:1	0.0049	0.037	2.47:1
10:45-11:00	0.0006	0.012	4:1	0.0001	0.003	1:1	0.0003	0.003	1:1	0.0084	0.007	2.33:1	0.0005	0.004	1.33:1
11:00-11:15	0.0001	0.002	1:1	0.0000	-	-	0.0001	0.001	<1:1	0.0022	0.002	1:1	0.0001	0.001	<1:1
11:15-11:30	0.0000	-	-	0.0000	-	-	0.0001	0.001	<1:1	0.0014	0.001	<1:1	0.0001	0.001	<1:1
11:30-11:45	0.0001	0.002	1:1	0.0000	-	-	0.0001	0.001	<1:1	0.0021	0.002	1:1	0.0002	0.001	<1:1
11:45-12:00	0.0002	0.004	1:1	0.0001	0.003	<1:1	0.0004	0.004	1:1	0.0058	0.005	1.25:1	0.0005	0.004	1:1
12:00-12:15	0.0007	0.014	1.75:1	0.0002	0.006	<1:1	0.0005	0.005	<1:1	0.0112	0.009	1.3:1	0.0012	0.009	1.13:1
12:15-12:30	0.0003	0.006	1.2:1	0.0001	0.003	<1:1	0.0004	0.004	<1:1	0.0060	0.005	1:1	0.0005	0.004	<1:1
12:30-12:45	0.0001	0.002	1:1	0.0000	-	-	0.0001	0.001	<1:1	0.0021	0.002	1:1	0.0002	0.001	<1:1
12:45-13:00	0.0000	-	-	0.0000	-	-	0.0001	0.001	1:1	0.0014	0.001	1:1	0.0001	0.001	1:1
18:00-21:00	0.0066	0.135	<1:1	0.0040	0.127	<1:1	0.0200	0.196	1.23:1	0.3963	0.309	1.94:1	0.0125	0.094	<1:1
21:00-24:00	0.0004	0.008	<1:1	0.0002	0.006	<1:1	0.0019	0.019	<1:1	0.0310	0.024	1.14:1	0.0008	0.006	<1:1
TOTAL	0.0489	-	-	0.0315	-	-	0.1019	-	-	1.284	-	-	0.1334	-	-

TABLE 25 (Continued)

Date/ Comments	Flow (m³)		LOADING (kg)											
			Suspended Solids			COD			TOC			Aluminum		
	Incremental⁺	I/T⁺⁺	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**
81/09/21														
16:45-17:00	0.9	0.005	0.004	0.001	<1:1	0.018	0.004	<1:1	0.005	0.004	<1:1	0.000	-	-
17:00-17:15	39.9	0.234	2.753	0.707	3.02:1	2.119	0.506	2.16:1	0.718	0.560	2.39:1	0.032	0.390	1.67:1
17:15-17:30	51.2	0.300	0.370	0.223	<1:1	1.674	0.400	1.33:1	0.358	0.279	<1:1	0.025	0.305	1.02:1
17:30-17:45	13.3	0.081	0.041	0.011	<1:1	0.281	0.067	<1:1	0.097	0.076	<1:1	0.003	0.037	<1:1
17:45-18:00	6.8	0.040	0.041	0.011	<1:1	0.139	0.033	<1:1	0.054	0.042	1.05:1	0.001	0.012	<1:1
18:00-18:15	6.3	0.040	0.054	0.014	<1:1	0.194	0.046	1.15:1	0.054	0.042	1.05:1	0.001	0.012	<1:1
TOTAL	170.5	-	3.393	-	-	4.137	-	-	1.282	-	-	0.082	-	-
81/10/26														
14:15-14:30	1.6	0.009	0.006	0.001	<1:1	0.029			0.008			0.000	-	-
14:30-14:45	1.6	0.009	0.152	0.036	4:1	<0.016	-	-	0.006			0.000	-	-
14:45-15:00	1.7	0.009	0.039	0.009	1:1	0.046			0.015			0.001	0.011	1.23:1
15:00-15:15	2.1	0.011	0.143	0.034	3.05:1	0.163	ACTUAL TOTAL GREATER THAN THEORETICAL		0.050	ACTUAL TOTAL GREATER THAN THEORETICAL		0.001	0.011	1.01:1
15:15-15:30	3.4	0.018	0.083	0.021	1.15:1	0.357			0.112			0.002	0.022	1.23:1
15:30-15:45	5.3	0.028	0.360	0.084	3.01:1	0.530			0.175			0.003	0.033	1.19:1
15:45-16:00	17.4	0.093	1.096	0.257	2.76:1	1.740			0.592			0.009	0.100	1.08:1
16:00-16:15	19.8	0.106	0.059	0.014	<1:1	6.060			1.822			0.012	0.133	1.26:1
16:15-16:30	20.3	0.111	0.399	0.117	1.05:1	1.329			0.374			0.007	0.078	<1:1
16:30-16:45	24.2	0.129	0.532	0.125	<1:1	0.995			0.315			0.007	0.078	<1:1
16:45-17:00	16.7	0.089	0.317	0.074	<1:1	0.610			0.200			0.005	0.055	<1:1
17:00-17:15	12.7	0.068	0.178	0.042	<1:1	0.406			0.114			0.003	0.033	<1:1
TOTAL	186.9	-	4.267	-	-	4.590	-	-	1.405	-	-	0.090	-	-

* Flush occurs when Ratio >1:1

** Ratio = $\frac{I/T^{++}\ (\text{Loading})}{I/T^{++}\ (\text{Flow})}$

⁺ From Table 13

⁺⁺ I/T refers to incremental divided by total, where total is:
(i) In the case of flow, the total flow for the storm.
(ii) In the case of load the total loading for the storm determined from the total flow and the flow-weighted mean concentration for all storms, shown in Table 13.

TABLE 25 (Continued)

Date/ Comments	LOADING (kg)														
	Lead			Copper			Zinc			Total Nitrogen			Total Phosphorus		
	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**	Incremental⁺	I/T⁺⁺	Ratio**
81/09/21															
16:45-17:00	0.0000	-	-	0.0000	-	-	0.0001	0.005	1:1	0.0018	0.007	1.36:1	0.0000	-	-
17:00-17:15	0.0070	ACTUAL TOTAL GREATER THAN THEORETICAL		0.0003	0.123	<1:1	0.0056	0.267	1.14:1	0.1197	0.453	1.94:1	0.0021	0.076	<1:1
17:15-17:30	0.0055			0.0015	0.231	<1:1	0.0061	0.290	<1:1	0.0701	0.265	<1:1	0.0021	0.076	<1:1
17:30-17:45	0.0005			0.0003	0.046	<1:1	0.0012	0.057	<1:1	0.0149	0.056	<1:1	0.0005	0.013	<1:1
17:45-18:00	0.0002			0.0002	0.031	<1:1	0.0008	0.038	<1:1	0.0071	0.027	<1:1	0.0003	0.011	<1:1
18:00-18:15	0.0003			0.0001	0.015	<1:1	0.0010	0.048	1.19:1	0.0065	0.025	<1:1	0.0006	0.022	<1:1
TOTAL	0.0101	-	-	0.0065	-	-	0.0210	-	-	0.2643	-	-	0.0275	-	-
81/10/26														0	
14:15-14:30	0.0000	-	-	0.0000	-	-	0.0001	0.004	<1:1	0.0019	0.007	<1:1	0.0001	0.000	<1:1
14:30-14:45	0.0000	-	-	0.0000	-	-	0.0001	0.004	<1:1	0.0048	0.017	1.84:1	0.0001	0.003	<1:1
14:45-15:00	0.0001	0.009	1:1	0.0000	-	-	0.0001	0.004	<1:1	0.0014	0.005	<1:1	0.0000	- 0	<1:1
15:00-15:15	0.0003	0.027	2.48:1	0.0001	0.014	1.28:1	0.0003	0.013	1.19:1	0.0063	0.022	2:1	0.0000	-	<1:1
15:15-15:30	0.0004	0.036	2:1	0.0001	0.014	<1:1	0.0005	0.022	1.21:1	0.0102	0.035	1.95:1	0.0001	0.00	-
15:30-15:45	0.0006	0.055	1.95:1	0.0002	0.023	1:1	0.0007	0.030	1.09:1	0.0159	0.055	1.96:1	0.0003	0.01	
15:45-16:00	0.0024	0.218	2.35:1	0.0007	0.099	1.06:1	0.0024	0.104	1.12:1	0.0522	0.180	1.94:1	0.0011	0.03	
16:00-16:15	0.0038	0.345	3.26:1	0.0010	0.141	1.33:1	0.0022	0.096	<1:1	0.0099	0.034	<1:1	0.0003	0.01	
16:15-16:30	0.0025	0.227	2.05:1	0.0006	0.085	<1:1	0.0019	0.083	<1:1	0.0264	0.091	<1:1	0.0013	0.06	
16:30-16:45	0.0031	0.282	2.13:1	0.0005	0.070	<1:1	0.0015	0.065	<1:1	0.0225	0.073	<1:1	0.0021	0.07	
16:45-17:00	0.0022	0.200	2.25:1	0.0003	0.042	<1:1	0.0012	0.052	<1:1	0.0157	0.054	<1:1	0.0013	0.04	
17:00-17:15	0.0010	0.091	1.34:1	0.0003	0.042	<1:1	0.0011	0.048	<1:1	0.0100	0.034	<1:1	0.0009	0.03	
TOTAL	0.0110	-	-	0.0071	-	-	0.0220	-	-	0.2900	-	-	0.0301	-	

* Flush occurs when Ratio >1

** Ratio = $\frac{I/T^{++}\ (\text{Loading})}{I/T^{++}\ (\text{Flow})}$

⁺ From Table 13

⁺⁺ I/T refers to incremental divided by total, where total is:
(i) In the case of flow, the total flow for the storm.
(ii) In the case of load the total loading for the storm determined from the total flow and the flow-weighted mean concentration for all storms, shown in Table 13.

TABLE 26

RELATIONSHIP OF LOADINGS FROM PRECIPITATION AND LOADINGS FROM DRY DEPOSITION AS MEASURED AT THE STORMWATER OUTFALL

Parameter	Precipitation		Dry Deposition	Ratio
	Concentration (mg/L) (From Table 4b)	Loading* $t/km^2/mo$	Loading $t/km^2/mo$ (from Table 5b)	$\frac{\text{Precipitation}}{\text{Dry Deposition}}$
Chloride	1.4	0.182	0.21	0.867
Sodium	0.81	0.105	0.11	0.958
Copper	0.016	0.00208	0.001	2.082
Lead	0.029	0.00377	0.0016	2.358
Zinc	0.057	0.00742	0.0057	1.301

* Calculated on basis of 1691.5 mm of rainfall (Table 3) over 1 km^2 area during 13 months.

TABLE 27

STORMWATER LOADINGS AND THEIR ORIGIN

Parameter	Total Loading Wet Weather (Table 24) (kg/d)	Loading Precipitation* (kg/d)	Loading in Dustfall** (kg/d)	Loading Balance in Runoff (kg/d)
Lead	0.017	0.006	0.007	0.004
Copper	0.009	0.004	0.004	0.001
Zinc	0.033	0.013	0.025	0.000
Total Nitrogen	0.26	0.27	-	0.000
Total Phosphorus	0.037	0.010	-	0.027

* Calculated on the basis of 1691.5 mm of rainfall (Table 3) over 12.95 hectares during 13 months, using the mean runoff coefficient of 0.40 (Table 9), and the mean concentrations in rainfall at the outfall, from Table 4b.

Sample Calculation: $\text{Total Lead} = (0.029 \text{ mg/L}) \dfrac{1691.5 \text{ mm} \times 12.95 \text{ ha} \times 0.4}{13 \text{ months} \times 30.5 \text{ d/month}}$

$= 0.0064 \text{ kg/d}$

** Determined from loading from precipitation by using the ratio calculated in Table 26 and compensating for the runoff coefficient used (i.e. assuming forty percent of precipitation is runoff).

Sample Calculation: $\text{Total Lead} = \dfrac{0.0064}{(0.4)(2.358)} = 0.0067$

- No data analyzed.

TABLE 28

COMPARISON OF STORMWATER LOADINGS* WITH THOSE FROM SEWAGE TREATMENT PLANTS

Parameter	Loading From All Residential Areas* kg/d	Average Loading From Iona, Lulu and Annacis** kg/d
COD	1 580	142 000
Metals: Aluminum	136	625
Copper	12.3	41
Lead	23.2	28
Zinc	45	94
Nitrogen - Total	354	13 910
Phosphorus - Total	50.4	2 334
Solids - Suspended	6 974	40 000

* From Table 24, for all residential areas within the Fraser River Estuary Study Area.

** From Cain and Swain(27), using data for 1979.

TABLE 29
STATISTICAL EVALUATION OF VARIABILITY OF PRECIPITATION QUALITY MEASUREMENTS BETWEEN SITES

	Raingauge Site to Outfall Site	Townhouse Site to Outfall Site	Townhouse Site to Raingauge Site
pH	n=102 Df=200 t=0.1172 P=0.9068 F=1.04 (101,99) P=0.8482	n=103 Df=201 t=-0.2164 |P|=0.8289 F=1.06 (102,98) P=0.7869	n=103 Df=203 t=-0.3320 |P|=0.7402 F=1.20 (103,101) P=0.9372
Calcium	n=49 Df=92 t=0.2012 P=0.8410 F=1.30 (48,44) P=0.3765	n=50 Df=93 t=0.8781 P=0.3821 F=2.39 (49,44) P=0.0040*	n=50 Df=97 t=0.7046 P=0.4827 F=1.83 (48,49) P=0.0376**
Potassium	n=53 Df=103 t=-3.1737 P=0.0020* F=190.91 (51,52) P=0.0001**	n=54 DF=104 t=-1.9305 |P|=0.0563 F=2.64 (51,53) P=0.0006**	n=54 Df=105 t=1.4903 P=0.1389 F=72.35 (53,52) P=0.0001**
Chloride	n=53 Df=103 t=-0.8089 |P|=0.4204 F=1.36 (51,52) P=0.2762	n=54 Df=104 t=-0.2438 |P|=0.8079 F=1.02 (51,53) P=0.9518	n=54 Df=105 t=0.5565 P=0.5791 F=1.33 (53,52) P=0.2993
Magnesium	n=49 Df=92 t=0.5824 |P|=0.5618 F=1.30 (44,48) P=0.3704	n=50 Df=93 t=0.1141 P=0.9094 F=1.04 (44,49) P=0.8906	n=50 Df=97 t=0.7127 P=0.4778 F=7.36 (49,48) P=0.2896
Phosphate	n=99 Df=194 t=-1.6609 |P|=0.0983 F=101.53 (96,98) P=0.0001**	n=100 Df=195 t=-1.7235 |P|=0.0864 F=58.81 (99,96) P=0.0001*	n=100 Df=197 t=0.5565 P=0.5791 F=1.33 (53,52) P=0.2993
Sodium	n=49 Df=92 t=0.2012 P=0.8410 F=1.30 (48,44) P=0.3765	n=50 Df=93 t=0.8781 P=0.3821 F=2.39 (49,44) P=0.0040**	n=50 Df=97 t=0.7046 P=0.4827 F=1.83 (48,49) P=0.0376**
Sulphate	n=49 Df=94 t=-2.8423 |P|=0.0055* F=2.46 (48,46) P=0.0026**	n=50 Df=97 t=1.4742 |P|=0.1437 F=1.30 (48,49) P=0.3703	n=50 Df=95 t=0.9054 P=0.3676 F=3.19 (49,46) P=0.0001*
Acidity - strong	n=75 Df=147 t=-0.6319 |P|=0.5285 F=1.60 (73,74) P=0.0451**	n=77 Df=149 t=-0.2517 |P|=0.8016 F=1.12 (73,76) P=0.6303	n=77 Df=150 t=0.3771 P=0.7067 F=1.43 (76,74) P=0.1226
Acidity - total	n=75 Df=147 t=-3.0990 |P|=0.0023* F=1.37 (73,74) P=0.1769	n=77 Df=149 t=-2.1046 |P|=0.0370* F=1.06 (76,73) P=0.7944	n=77 Df=150 t=0.8051 P=0.4221 F=1.46 (76,74) P=0.1049

TABLE 29 (Continued)

	Raingauge Site to Outfall Site	Townhouse Site to Outfall Site	Townhouse Site to Raingauge Site
Nitrite Nitrogen	n=61 Df=119.0 t=1.6914 P=0.0934 F=1.68 (60,59) P=0.0470**	n=62 Df=120 t=2.3434 P=0.0208* F=1.49 (61,59) P=0.1290	n=62 Df=121 t=0.5167 P=0.6063 F=1.13 (61,60) P=0.6278
Nitrate Nitrogen	n=100 Df=195 t=0.7218 P=0.4713 F=2.30 (96,99) P=0.0001**	n=100 Df=195 t=-0.2915 1P1=0.7710 F=2.20 (96,99) P=0.0001**	n=100 Df=198 t=0.5467 P=0.5852 F=1.04 (99,99) P=0.8299
Ammonium Nitrogen	n=100 Df=195 t=-1.0391 1P1=0.300 F=11.27 (96,99) P=0.0001**	n=100 Df=d195 t=-0.5286 1P1=0.5977 F=7.65 (96,99) P=0.0001**	n=100 Df=198 t=1.1154 P=0.2661 F=1.47 (99,99) P=0.0555
Cadmium	n=66 Df=128 t=-0.2100 1P1=0.8340 F=3.09 (65,63) P=0.0001**	n=67 Df=129 t=-0.1720 1P1=0.8637 F=2.41 (66,63) P=0.0006**	n=67 Df=131 t=0.0601 P=0.9522 F=1.62 (65,66) P=0.0535
Copper	n=66 Df=128 t=-2.5971 1P1=0.0105* F=4.51 (63,65) P=0.0001**	n=67 Df=129 t=-1.7919 P=0.0755 F=2.61 (63,66) P=0.0001**	n=67 Df=131 t=0.9963 P=0.3209 F=1.73 (66,65) P=0.0280**
Lead	n=65 Df=127 t=0.6411 P=0.5226 F=2.54 (64,63) P=0.0003**	n=66 Df=128 t=1.6064 1P1=0.1107 F=2.92 (65,63) P=0.0001**	n=66 Df=129 t=0.8504 1P1=0.3967 F=1.15 (65,64) P=0.5763
Zinc	n=66 Df=129 t=0.2656 P=0.7910 F=9.07 (65,64) P=0.0001**	n=67 Df=130 t=-0.5867 1P1=0.5584 F=2.62 (66,64) P=0.0001**	n=67 Df=131 t=-0.5793 P=0.5634 F=3.46 (66,65) P=0.0001**

Reject the t-test Ho: $u_1=u_2$ (rejected at 0.05 level of probability).
**Reject the F-test Ho: B=0 (rejected at 0.05 level of probability).

egend

n: number of values
Df: degrees of freedom
: probability

TABLE 30
STATISTICAL EVALUATION OF VARIABILITY OF DUSTFALL QUALITY BETWEEN SITES

Parameters+	SITES TESTED		
	Rainguage Site to Outfall Site	Townhouse Site to Outfall Site	Townhouse Site to Rainguage Site
Total Particulate	t=2.6828 1P1=0.0121* Df=28 F=5.48 (12,16) P=0.0021**	t=-1.2691 1P1=0.2152 Df=27 F=1.88 (12,15) P=0.2467	t=1.5214 1P1=0.1383 Df=31 F=2.91 (15,16) P=0.0414**
Soluble Particulate	t=-1.7168 1P1=0.0971 Df=28 F=6.69 (12,16) P=0.0007**	t=-0.9977 1P1=0.3273 Df=27 F=2.17 (12,15) P=0.1592	t=0.7412 1P1=0.4641 Df=31 F=3.09 (16,15) P=0.0316**
Insoluble Particulate	t=-4.8483 1P1=0.0001* Df=28 F=1.77 (12,16) P=0.2849	t=-1.8357 1P1=0.0774 Df=27 F=1.02 (12,15) P=0.9614	t=2.8376 1P1=0.0079* Df=31 F=1.74 (14,16) P=0.2824
Soluble Ash	t=-2.3115 1P1=0.0284* Df=28 F=2.65 (12,16) P=0.0714	t=-1.9424 1P1=0.0626 Df=27 F=3.28 (12,15) P=0.0326**	t=0.5668 P=0.5749 Df=31 F=1.24 (16,15) P=0.6815
Insoluble Ash	t=-0.9407 1P1=0.3549 Df=28 F=1.22 (12,16) P=0.7027	t=3.2969 P=0.0028* Df=27 F=2.35 (12,15) P=0.1419	t=4.4957 P=0.0001* Df=31 F=2.86 (16,15) P=0.0448**
Soluble Chloride	t=-0.2081 1P1=0.83661 Df=30 F=1.49 (14,16) P=0.4435	t=0.6923 P=0.4941 Df=30 F=1.36 (16,14) P=0.5665	t=0.9678 1P1=0.3404 Df=32 F=2.03 (16,16) P=0.1687
Soluble Sodium	t=-0.2666 1P1=0.7916 Df=30 F=1.12 (14,16) P=0.8233	t=0.1370 P=0.8920 Df=30 F=1.37 (16,14) P=0.5585	t=0.3968 P=0.6942 Df=32.0 F=1.53 (16,16) P0.4022
Total Copper	t=0.3553 P=0.7250 Df=28 F=2.14 (13,15) P=0.1606	t=-0.479 1P1=0.9621 Df=29 F=1.11 (13,16) P=0.8311	t=-0.4377 1P1=0.6646 Df=31 F=1.93 (16,15) P=0.2115
Soluble Copper	t=0.0331 P=0.9738 Df=30 F=2.99 (14,16) P=0.0389**	t=-0.4237 P=0.6748 Df=30 F=1.75 (14,16) P=0.2837	t=-0.6116 1P1=0.5451 Df=32 F=1.71 (16,16) P=0.2946
Insoluble Copper	t=-0.1105 1P1=0.9128 Df=28 F=2.45 (13,15) P=0.0999	t=1.5443 P=0.1334 Df=29 F=2.24 (16,13) P=0.1489	t=1.8673 P=0.0713 Df=31 F=5.48 (16,15) F=0.0020**

TABLE 30 (Continued)

Parameters+	SITES TESTED		
	Rainguage Site to Outfall Site	Townhouse Site to Outfall Site	Townhouse Site to Rainguage Site
Total Lead	t=1.2105 P=0.2356 Df=30 F=1.72 (16,14) P=0.3147	t=6.6632 P=0.0001* Df=30 F=7.88 (16,14) P=0.0004**	t=6.1170 P=0.0001* Df=32 F=4.59 (16,16) P=0.0041**
Soluble Lead	t=0.9585 P=0.3455 Df=30 F=1.88 (16,14) P=0.2409	t=4.0452 P=0.0003* Df=30 F=12.0 (16,14) P=0.0001**	t=3.7016 P=0.0008* Df=32 F=6.41 (16,16) P=0.006**
Insoluble Lead	t=0.1413 1P1=0.8886 Df=30 F=1.88 (16,14) P=0.2418	t=2.4795 P=0.0190 Df=30 F=10.86 (16,14) P=0.0001**	t=2.4683 P=0.0191* Df=32 F=5.78 (16,16) P=0.0011**
Soluble Mercury	t=0.7211 P=0.4942 Df=7 F=1.47 (3,4) P=0.6975	t=1.1930 P=0.2717 Df=7 F=1.15 (4,3) P=0.9448	t=0.6565 P=0.5999 Df=8 F=1.70 (4,4) P=0.6207
Total Zinc	t=-2.0656 P=0.0476* Df=30 F=7.02 (14,16) P=0.0004	t=-1.4299 1P1=0.1631 Df=30 F=4.75 (14,16) P=0.0039**	t=1.0658 1P1=0.2945 Df=32 F=1.48 (16,16) P=0.4430
Soluble Zinc	t=-1.7489 1P1=0.0905 Df=30 F=8.35 (14,16) P=0.0001**	t=-1.1568 1P1=0.2565 Df=30 F=4.98 (14,16) P=0.0030**	t=1.0258 P=0.3127 Df=32 F=1.68 (16,16) P=0.3115
Insoluble Zinc	t=-0.7615 1P1=0.4523 Df=30 F=4.03 (14,16) P=0.0093**	t=-0.6072 1P1=0.5483 Df=30 F=1.84 (14,16) P=0.2414	t=0.1008 1P1=0.9203 Df=32 F=2.19 (16,16) P=0.1281

Legend

Df = degrees of freedom
P = probability
+ Parameters tested were those for which constant values were not recorded in Table 5.
* Reject "t test" Ho:$\mu_1=\mu_2$ at $P<0.05$
**Reject "F" test Ho:B=0 at $P<0.05$

APPENDIX I

FLOW COMPARISONS

Flows were recorded at Rupert and Rosemont on a total of 355 complete days. During these days a total flow of 162 190 m^3 was recorded passing through the flume. If the average base flow on completely dry days, based upon 159 days when no precipitation was measured, was 109 m^3/day, the flow due to runoff from rainfall would be: 162 190 - 109 X 355 = 123 450 m^3 for 355 days of the year.

Extrapolating to 365 days means that (365/355)(123 450 m^3) = 126 930 m^3/yr (348 m^3/d) would pass through the flume due solely to runoff from rainfall.

For all of the residential catchment areas draining to the Fraser River, calculated by Ferguson and Hall(3) to equal 17 640 ha, this would represent a flow of (17 640 ha/12.95 ha)(126 930 m^3/yr.) = 1.73 X 10^8 m^3/yr.

NORMAL FLOWS

Ferguson and Hall(3) had predicted a yearly flow from stormwater of 1.191 x 10^8 m^3/yr. This prediction was based upon average rainfall.

The difference between actual and predicted is 53 799 240.

Percent Difference $\left(\frac{53\ 799\ 240}{119\ 100\ 000}\right) \times 100\% = 45.2\%$ of predicted value

Note: The data in Table 3 indicate a heavier than normal rainfall for the period of study, by 37.1%.

APPENDIX II

SUSPENDED SOLIDS

This section is mainly concerned with the degree to which levels of chemical substances transported in runoff may be correlated with suspended solids, and antecedent dry days. The correlations emphasize the relationship between the metal constituents, the suspended inorganic, and the total suspended solids.

Sartor and Boyd studied street surface runoff for 12 U.S. cities$^{(1)}$. They observed this runoff to be highly contaminated, with the major constituent being inorganic, mineral-like matter similar to common sand or silt. The fine residual fraction of the street accumulated material was recognized as containing most of the contaminants.

The EPA observed that 85% of the suspended solids entering receiving waters in Tulsa, Oklahoma could be attributed to stormwater discharges$^{(2)}$. The Thames River Basin study also found that problems related to suspended solids could be attributed to stormwater and combined stormwater overflow discharges$^{(3)}$.

Stancil (1980) identified solids from stormwater discharges as the main source of metal loadings to the Fraser River$^{(4)}$. Franson examined the environmental quality of Vancouver's runoff and treated domestic sewage discharges and concluded that other than natural sediment transport, stormwater was the major source of suspended solids to the surrounding receiving waters$^{(5)}$.

Runoff data were collected from six urban drainage basins in the Seattle Area by Zision in 1980$^{(6)}$. Regression analyses were used to delineate suspended solids and water chemistry relationships, as well as to compare watershed characteristics to runoff quality. Zision's analytical procedure was the basis of the methodology used to evaluate the suspended constituents of the Urban Stormwater Runoff Computer Model(7).

Samples from four runoff events were collected and analyzed for selected water chemistry parameters and suspended solids. A regression analysis model was used to relate suspended solids concentrations, concentrations of certain constituents in stormwater, antecedent dry days, and flow rates.

The regression analysis used the simple and multiple forms of the program to determine the best fitting relationship between variables in the data set. The simple linear model (Equation 1) was used primarily to determine whether there was any nonlinearity in the data and to test certain regression assumptions describing the quality of the relationships.

$$C = b + ms \quad \ldots \; (1)$$

Where

C = dependent variable
s = independent variable
b = the line intercept
m = slope of the line

If these assumptions were met, then a multiple regression program (Equation 2) could be implemented. The computer program used to make these determinations utilized the principle of least squares and the stepwise method to fit the model which best described the relationships between suspended solids and parameters governing their concentrations. This form of regression analysis introduced the independent variables one at a time, and for each variable, generated all the statistical requirements (Table 11-1).

Where $y = b_0 + b_1x_1 \ldots b_nx_n \quad \ldots (2)$

y = the predicted value of the dependent variable

x_n = the observed values of the independent variables

$b_0, b_1 \ldots b_n$ = the fitted coefficients

The simple regression analysis was used to generate the relationships between individual suspended water chemistry constituents, suspended solids and water chemistry constituents, suspended solids and flow, and water chemistry constituents and flow. Table 11-3 contains the results of the multiple regression analyses which included the measurement of antecedent dry weather and its relationship to the water chemistry and suspended solids constituents discharging from the stormwater outfall.

SIMPLE REGRESSION

COPPER

The r^2 value of 0.3312 in conjunction with the "F" test analysis ($F = 13.87$; $P = 0.0009$) indicated a strong correlation between suspended copper and suspended zinc values listed in Table 18. The correlation between suspended iron and suspended copper ($F = 5.06$; $P = 0.0325$) was weaker, however, the variability in the suspended iron concentrations was not adequately represented by the fitted regression ($r^2 = 0.1531$). Concentrations of total copper ($r^2 = 0.0601$), and total suspended solids ($r^2 = 0.0685$), and flow rate values ($r^2 = 0.0173$) were not significantly related to suspended copper concentrations. The average concentration of suspended copper was 0.0073 mg/L for a range of values from 0.001 mg/L to 0.020 mg/L.

IRON

In general, the simple regression analysis demonstrated that many factors govern the concentrations of suspended iron (average value, 1.90

mg/L; range, 0 mg/L to 7173 mg/L). The most significant correlations for suspended iron were those with total iron concentrations ($r^2 = 0.999$; F = 59851.29; P = 0.0001), and total suspended solids ($r^2 = 0.868$; F = 184.17; P = 0.001). Flow rate was significantly correlated with suspended iron ($r^2 = 0.2773$; F = 10.75; P = 0.0028).

LEAD

Lead concentrations ranged from 0.001 mg/L to 0.037 mg/L (mean value, 0.0216 mg/L). Total lead was strongly correlated with suspended lead ($r^2 = 0.9623$; F = 715.4; P = 0.0001) and to a lesser extent with total suspended solids ($r^2 = 0.1393$; F = 4.53; P = 0.0422). The rate of flow was not significantly correlated with suspended lead concentrations. No significant correlations existed between other suspended metals and suspended lead.

ZINC

The regression analysis showed no significant correlation between suspended zinc (mean value 0.024 mg/L; range, 0 to 0.07 mg/L) and suspended solids or flow rate.

INORGANIC SUSPENDED SOLIDS

Total suspended solids ($r^2 = 0.9893$; F = 2590.01; P = 0.0001), specific conductance ($r^2 = 0.8145$; F = 123.10; P = 0.0001), organic carbon ($r^2 = 0.7047$; F = 66.82; P = 0.0001), total phosphorus ($r^2 = 0.6251$; F = 46.70; P = 0.0001), and total nitrogen ($r^2 = 0.54$; F = 32.82; P = 0.0001) were strongly correlated with inorganic suspended solids (mean value, 7.833 mg/L; range, 1 mg/L to 31 mg/L). Ammonia, nitrate/nitrite, total dissolved phosphorus, and flow rate were also observed to be significantly correlated with inorganic suspended solids. The number of antecedent dry days ($r^2 = 0.1180$; F = 3.75; P = 0.0631) was not significant.

TOTAL SUSPENDED SOLIDS

The mean value for the total suspended solids was 13.9 mg/L for a range of values from 2 mg/L to 46 mg/L.

The correlations between total suspended solids and the number of antecedent dry days (F = 5.32; P = 0.0287), and between total suspended solids and ammonia (F = 6.83, P = 0.0143), were not significant. The variability in these constituents could not be accounted for by the fitted regression (r^2 value for ammonia = 0.1960, and r^2 value for antecedent dry days = 0.1597).

The fitted regressions for total suspended solids and nitrate/nitrite values (r^2 = 0.2480; F = 9.24; P = 0.0051) and total suspended solids and flow rate (r^2 = 0.339; F = 8.55; P = 0.0068) explained some of the variability. The strongest correlations were between total suspended solids and specific conductance (r^2 = 0.7543; F = 85.93; P = 0.0001), organic carbon (r^2 = 0.6785; F = 59.01; P = 0.0001), total phosphorus (r^2 = 0.6635; F = 55.21; P = 0.0001), total dissolved phosphorus (r^2 = 0.37; F = 16.10; P = 0.0004), and total nitrogen (r^2 = 0.5021; F = 28.32; P = 0.0001).

MULTIPLE REGRESSION

The forward r^2 form of the stepwise regression was used to determine which of the independent variables sampled had a significant influence on the suspended solids concentrations. This form of the regression uses as many variables as are required to show which bring about a significant change in the dependent variable (see Table 11-3). The computer program examined the null hypothesis that the regression coefficient would equal zero. If the F value for each test exceeded the critical value, the independent variables had a significant effect on the value of the dependent variable. The independent variable was subsequently added to the model. However, if the F value was less than the critical value, the independent variable associated with that F value was not included in the fitted regression equation.

COPPER

The best fitted equation for suspended copper incorporated the variable of suspended iron, suspended zinc, and flow ($r^2 = 0.5352$). The r^2 value indicated that a large percentage of the variability in suspended copper was not accounted for by this equation compared to the equations derived for other suspended constituents.

IRON

The simple regression analysis identified total iron and total suspended solids to be strongly correlated with suspended iron ($r^2 = 0.995$, $r^2 = 0.8680$, respectively). At this level of correlation, the majority of the variability in suspended iron was accounted for by the independent variables. The multiple regression equation with the best fit included the number of antecedent dry days, suspended copper, total iron, flow, and total suspended solids ($r^2 = 0.999$). As well, suspended lead values correlated well as an independent variable with total suspended solids, flow, and total iron ($r^2 = 0.998$).

LEAD

Suspended copper and total lead values were strongly correlated with suspended lead values ($r^2 = 0.9713$). The lesser correlation with total suspended solids was not demonstrated by the multiple regression as it was in simple linear regression.

ZINC

The model using one variable showed suspended copper values as having the highest correlation with suspended zinc ($r^2 = 0.3312$). The fitted equation with the highest correlation was the three variable model using the independent variables of suspended iron, suspended lead, and total suspended solids ($r^2 = 0.5252$). Two other three variable model regressions were derived correlating suspended copper, suspended iron, and inorganic suspended solids with suspended zinc ($r^2 = 0.5118$). The correlation did not account for a significant proportion of the variability in the concentrations of suspended zinc.

INORGANIC SOLIDS

Suspended iron, suspended lead, the number of antecedent dry days, flow, and total suspended solids gave the five variable equation of best fit for inorganic suspended solids ($r^2 = 0.9980$). The four variable model provided the best fitting equation to describe the relationships between ammonia, organic carbon, specific conductance, total phosphorus and inorganic suspended solids ($r^2 = 0.943$).

TOTAL SUSPENDED SOLIDS

The strongest correlation for total suspended solids was with flow, inorganic suspended solids, suspended iron, suspended lead, and antecedent dry days ($r^2 = 0.9976$). Specific conductance, organic carbon, total phosphorus, flow, ammonia, and the number of antecedent dry days gave the best correlation with the organic constituents and total suspended solids values.

TABLE 11-1
REGRESSION EQUATIONS FOR WATER QUALITY CONSTITUENTS

		r^2
1.	Total Fe = 1.0313 (S.Fe) + 0.0307	0.999
2.	S.Fe = 0.1366 (T.S.S.) - 0.7145	0.868
3.	S.Fe = -0.0494 (Flow) + 2.8337	0.2773
4.	Total Pb = 1.2800 (S. Pb) + 0.0039	0.9623
5.	I. S.S. = 0.2211 (Flow) + 15.1952	0.2714
6.	I. S.S. = 0.6604 (T.S.S.) - 1.3681	0.9893
7.	S.Cu = 0.1706 (S.Zn) + 0.0032	0.3312
8.	TOC = 0.9465 (T.S.S.) - 1.6193	0.6785
9.	TOC = 1.4525 (I. S.S.) + 0.1885	0.7047
10.	NO_2/NO_3 = 0.0119 (I. S.S.) + 0.3018	0.3018
11.	T.N. = 0.0470 (T.S.S.) + 0.8895	0.5021
12.	T.N. = 0.0734 (I. S.S.) + 0.9693	0.5400
13.	T. Dis.P = 0.0003 (T.S.S.) + 0.0179	0.3650
14.	T. Dis.P = 0.0005 (I. S.S.) + 0.0187	0.3450
15.	T.P. = 0.0056 (T.S.S.) + 0.0187	0.6635
16.	T.P. = 0.0082 (I. S.S.) + 0.0326	0.6251
17.	S.C. = 2.173 (T.S.S.) + 24.189	0.7543
18.	S.C. = 3.4014 (I. S.S.) + 27.8220	0.8145
19.	Total Fe = 0.0517 (Flow) + 2.9805	0.2862
20.	Total Zn = 0.0011 (Flow) + 0.1450	0.4605
21.	S.C. = 0.8485 (Flow) + 82.7176	0.2814
22.	TOC = 0.3553 (Flow) + 23.3965	0.2341

EXPLANATION OF SYMBOLS

Total Fe = Total Iron, g/L
S.Fe = Suspended Iron, mg/L
Total Pb = Total Lead, mg/L
S.Pb = Suspended Lead, mg/L
T.S.S. = Total Suspended Solids, mg/L
I. S.S. = Inorganic Suspended Solids, mg/L
S. Cu = Suspended Copper, mg/L
S. Zn = Suspended Zinc, mg/L
TOC = Total Organic Carbon, mg/L
NO_2/NO_3 = Nitrite/Nitrate, mg/L
T.N. = Total Nitrogen, mg/L
T.Dis.P = Total Dissolved Phosphorus, mg/L
T.P. = Total Phosphorus, mg/L
S.C. = Specific Contuctance, μS/cm
Total Zn = Total Zinc, mg/L
Flow = m^3

TABLE 11-2
RESULTS OF THE SIMPLE LINEAR REGRESSION ANALYSES

Slope m	Intercept b	r^2	F-test		Standard Error of Estimate	Parameter
			F	P		
-0.8485	82.7176	0.2814	10.97	0.0026*	32.3654	Specific Conductance on Flow
-0.3553	23.3965	0.2341	8.56	0.0068*	15.3428	Organic Carbon on Flow
-0.0008	0.08324	0.0578	1.72	0.2008	0.0731	Ammonia on Flow
-0.0028	0.5323	0.0891	2.74	0.1091	0.2101	Nitrate/Nitrite on Flow
-0.0078	1.8034	0.0338	0.98	0.3308	0.9944	Total Nitrogen on Flow
-0.0016	0.1512	0.1373	4.46	0.0439*	0.0976	Total Phosphorus on Flow
-0.0002	0.0283	0.2234	8.05	0.0084*	0.0076	Total Dissolved Phosphorus of Flow
-0.0003	0.0287	0.2196	7.88	0.009*	0.0126	Copper on Flow
-0.0517	2.9805	0.2862	11.23	0.0023*	1.9508	Iron on Flow
4.8961×10^{-5}	0.0299	0.0019	0.05	0.8188	0.0267	Lead on Flow
-0.0011	0.1450	0.4605	23.90	0.0001*	0.0287	Zinc on Flow

*Reject H_0 B=0 at the probability level of 5%

TABLE 11-2 (Continued)
RESULTS OF THE SIMPLE LINEAR REGRESSION ANALYSES

Slope m	Intercept b	r^2	F-test		Standard Error of Estimate	Parameter
			F	P		
0.6322	0.0148	0.0601	1.79	0.1917	0.0138	Total Copper on Suspended Copper
9.4716X 10^{-5}	0.0059	0.0685	2.06	0.1624	0.0053	Suspended Copper on Total Suspended Solids
3.043X 10^{-5}	0.0063	0.0173	0.49	0.4883	0.0055	Suspended Copper on Flow
1.0313	0.0307	0.999	59851.29	0.0001*	0.0499	Total Iron on Suspended Iron
0.1366	-0.7145	0.868	184.17	0.0001*	0.8131	Suspended Iron on Total Suspended Solids
-0.0494	2.8337	0.2773	10.75	0.0028*	1.9028	Suspended Iron on Flow
1.2800	0.0039	0.9623	715.40	0.0001*	0.0052	Total Lead on Suspended Lead
0.0005	0.0146	0.1393	4.53	0.0422*	0.0190	Suspended Lead on Total Suspended Solids
5.5178X 10^{-5}	0.0197	0.0041	0.12	0.7361	0.0205	Suspended Lead on Flow
0.5802	0.0941	0.0763	2.31	0.1395	0.0376	Total Zinc on Suspended Zinc
3.1902X 10^{-5}	0.0236	0.0007	0.02	0.891	0.0186	Suspended Zinc on Total Suspended Solids
-5.556X 10^{-5}	0.02585	0.0051	0.14	0.7085	0.0186	Suspended Zinc on Flow

*Reject H_0 B=0 at the probability level of 5%

TABLE 11-2
RESULTS OF THE SIMPLE LINEAR REGRESSION ANALYSES

Slope M	Intercept b	r^2	F-test & Prob.		Standard Error of Estimate	Parameter
			F	P		
0.2211	15.1952	0.2714	10.43	0.0032*	8.6481	Inorganic Suspended Solids on Flow
0.3091	24.2258	0.2339	8.55	0.0068*	13.3566	Total Suspended Solids on Flow
0.6604	-1.3681	0.9893	2590.01	0.0001*	1.0478	Inorganic Suspended Solids on Total Suspended Solids
0.0792	0.0056	0.0866	2.65	0.1145	0.0053	Suspended Copper on Suspended Lead
0.1706	0.0032	0.3312	13.87	0.0009*	0.0045	Suspended Copper on Suspended Zinc
158.5876	0.03726	0.1531	5.06	0.0325*	2.0598	Suspended Iron on Suspended Copper
0.0019	0.0217	0.0547	1.62	0.2133	0.0181	Suspended Zinc on Suspended Lead
0.0018	0.0194	0.0392	1.14	0.2940	0.0201	Suspended Lead on Suspended Iron
-1.2917	24.2667	0.1597	5.32	0.0287*	13.9882	Suspended Solids on Antecedent Dry Days
-0.7372	13.7308	0.1180	3.75	0.0631	9.5151	Inorganic Suspended Solids on Antecedent Dry Days
0.9465	-1.6193	0.6785	59.10	0.0001*	9.9395	Total Suspended Solids on Organic Carbon
1.4524	0.1885	0.7047	66.82	0.0001*	9.5268	Inorganic Suspended Solids on Organic Carbon
0.0022	0.0276	0.1960	6.83	0.0143*	0.06752	Suspended Solids on Ammonia
0.0036	0.0298	0.2345	8.58	0.0067*	0.0659	Inorganic Suspended on Ammonia

*Reject H_o B=0 at the probability level of 5%

TABLE 11-2
RESULTS OF THE SIMPLE LINEAR REGRESSION ANALYSES FOR SUSPENDED CONSTITUENTS

Slope M	Intercept b	r^2	F-test & Prob.		Standard Error of Estimate	Parameter
			F	P		
0.0072	0.3406	0.2480	9.24	0.0051*	0.1909	Total Suspended Solids on Nitrite-Nitrate
0.0119	0.3472	0.3018	12.10	0.0017*	0.1839	Inorganic Suspended Solids on Nitrite-Nitrate
0.0470	0.8895	0.5021	28.23	0.0001*	14.3868	Suspended Solids on Total Nitrogen
0.0734	0.9693	0.5400	32.86	0.0001*	15.4724	Inorganic Suspended Solids on Total Nitrogen
0.0003	0.0179	0.3650	16.10	0.0004*	0.0069	Suspended Solids on Total Dissolved Phosphorus
0.005	0.0187	0.3450	14.75	0.0006*	0.0069	Inorganic Suspended Solids on Total Dissolved Phosphorus
0.0056	0.0187	0.6635	55.21	0.0001*	0.06094	Suspended Solids on Total Phosphorus
0.0082	0.0326	0.6251	46.70	0.0001*	0.0643	Inorganic Suspended Solids on Total Phosphorus
2.1730	24.1890	0.7543	85.95	0.0001*	18.9265	Suspended Solids on Specific Conductance
3.4014	27.8220	0.8145	123.10	0.0001*	16.4358	Inorganic Suspended Solids on Specific Conductance

*Reject H_0 B=0 at the probability level of 5%

TABLE 11-3

REGRESSION EQUATIONS FITTED BY THE FORWARD STEPWISE

			r^2
1.	S.Cu	= -0.0010+0.0012(S.Fe)+0.1447(S.Zn)+0.0001(Flow)	0.5352
2.	S.Fe	= -0.0370+1.0156(T.Fe)+0.0012(Flow)-0.0065(T.S.S.)	0.99986
3.	S.Fe	= -0.0370-0.6319(S.Pb)+1.010(T.Fe)+0.0013(Flow)-0.0052(T.S.S.)	0.99988
4.	S.Fe	= -0.0608+0.0030(A.D.D.)-2.9003(S.Cu)=1.0198(T.Fe)+0.0015(Flow)-0.0061(T.S.S.)	0.9999
5.	S.Pb	= -0.0042=0.3591(S.Cu)+0.7366(T.Pb)	0.9623
6.	S.Zn	= -0.0063+1.9955(S.Cu)+0.1461(T.Zn)	0.4252
7.	S.Zn	= 0.0208+1.3537(S.Cu)+0.0125(S.Fe)-0.0028(I.S.S.)	0.5071
8.	S.Zn	= 0.269+0.0208(S.Fe)+0.3568(S.Pb)-0.0045(I.S.S.)	0.5118
9.	S.Zn	= 0.0296+0.0182(S.Fe)+0.4781(S.Pb)-0.0027(T.S.S.)	0.5252
10.	I.S.S.	= -1.3814+0.0764(A.D.D.)+0.5535(S.Fe)-22.9438(S.Pb)+0.6057(T.S.S.)	0.9976
11.	I.S.S.	= -1.0006+0.0764(A.D.D.)-0.0102(Flow)+0.5191(S.Fe)-20.2333(S.Pb)+0.6014(T.S.S.)	0.9980
12.	T.S.S.	= 2.4799-0.1374(A.D.D.)+40.6416(S.Pb)-0.6737(S.Fe)+1.5929(I.S.S.)	0.9972
13.	T.S.S.	= 1.8742-0.1366(A.D.D.)+0.0158(Flow)+36.2764(S.Pb)-0.6621(S.Fe)+1.6126(I.S.S.)	0.9976
14.	T.S.S.	= 0.5421-104.6734(NH_4)+25.0209(T.P)+0.7736(TOC)+0.1485(S.C)	0.9665
15.	T.S.S.	= -0.6527+255.2116(T.Cu)+124.8420(T.Pb)+4.5341(T.Fe)	0.9345
16.	I.S.S.	= -2.0722-55.5462(NH_4)+14.7941(T.P)+0.4419(TOC)+0.1209(S.C.)	0.9743
17.	I.S.S.	= -0.93697+157.6895(T.Cu)+3.2406(T.Fe)+51.9202(T.Pb)	0.9472

TABLE 11-3 (Continued)

EXPLANATION OF SYMBOLS

S.Cu = Suspended Copper (mg/L)
S.Fe = Suspended Iron (mg/L)
S.Pb = Suspended Lead (mg/L)
S.Zn = Suspended Zinc (mg/L)
I.S.S. = Inorganic Suspended Solids (mg/L)
T.S.S. = Total Suspended Solids (mg/L)
Flow = (m^3)
A.D.D. = Antecedent Dry Days
T.Fe = Total Iron (mg/L)
T.Pb = Total Lead (mg/L)
T.Cu = Total Copper (mg/L)
NH_4 = Ammonia (mg/L)
T.P = Total Phosphorus (mg/L)
TOC = Total Organic Carbon (mg/L)
S.C. = Specific Conductance (μS/cm)
* = Reject H_0:B=0 at the probability level of 5%

TABLE 11-4
RESULTS OF THE FORWARD STEPWISE REGRESSION ANALYSIS

Intercept	Slope	r^2	F-test		Parameters
"b"	"m"		F	P	
SUSPENDED COPPER:					
0.0032		0.3312			Best 1 variable model
	0.1706		13.87	0.0009*	Suspended Zinc
0.0029		0.4009			Best 2 variable model
	0.0007		3.14	0.0877	Suspended Iron
	0.1517		11.17	0.0025*	Suspended Zinc
-0.0010		0.5352			Best 3 variable model
	0.0012		9.74	0.0044*	Suspended Iron
	0.1447		12.55	0.0015*	Suspended Zinc
	0.0001		7.52	0.0109*	Flow
-0.0013		0.5462			Best 4 variable model
	0.0012		7.86	0.0096*	Suspended Iron
	0.0295		0.61	0.4435	Suspended Lead
	0.1420		11.83	0.0021*	Suspended Zinc
	0.0001		6.32	0.0188*	Flow
0.0007		0.5957			Best 5 variable model
	0.0028		3.27	0.0831	Suspended Lead
	0.0726		8.62	0.0072*	Suspended Zinc
	0.0944		8.93	0.0064*	Flow
	0.0001		5.41	0.0288*	Inorganic Suspended Solids
	-0.0003		4.48	0.0449*	Total Suspended Solids
0.0009		0.6078			Best 6 variable model
	0.0001		0.71	0.4078	Suspended Iron
	0.1114		3.74	0.0657	Suspended Lead
	0.0986		3.07	0.0930	Suspended Zinc
	0.0001		7.94	0.0098*	Flow
	0.0019		2.15	0.1559	Inorganic Suspended Solids
	-0.0014		3.04	0.0944	Total Suspended Solids

TABLE 11-4 (Continued)

Intercept "b"	Slope "m"	r^2	F-test		Parameters
			F	P	
0.0006		0.6085			Best 7 variable model
	0.0014		0.65	0.4284	Suspended Iron
	0.1137		3.58	0.0717	Suspended Lead
	0.0993		2.97	0.0988	Suspended Zinc
	0.0227		0.04	0.8494	Total Copper
	0.0001		7.47	0.0121*	Flow
	0.0019		1.97	0.1743	Inorganic Suspended Solids
	-0.0014		2.90	0.1028	Total Suspended Solids
0.0002		0.6089			Best 8 variable model
	0.00004		0.03	0.8739	Antecedent Dry Days
	0.0015		0.65	0.4307	Suspended Iron
	0.1125		3.31	0.0833	Suspended Lead
	0.0966		2.50	0.1289	Suspended Zinc
0.00017		0.6089			Best 8 variable model
	0.0281		0.05	0.8251	Total Copper
	0.0001		6.36	0.0198*	Flow
	0.0017		0.98	0.3330	Inorganic Suspended Solids
	-0.0013		1.46	0.2397	Total Suspendeds Solids
SUSPENDED IRON:					
-0.0292		0.9995			Best 1 variable model
	0.9629		59851.29	0.0001*	Total Iron
0.0088		0.9997			Best 2 variable model
	1.0075		14172.02	0.0001*	Total Iron
	-0.0062		23.31	0.0001*	Total Suspended Solids
-0.0370		0.99986			Best 3 variable model
	1.0156		23324.45	0.0001*	Total Iron
	0.0012		21.10	0.0001*	Flow
	-0.0065		44.10	0.0001*	Total Suspended Solids

TABLE 11-4 (Continued)

Intercept "b"	Slope "m"	r^2	F-test		Parameters
			F	P	
-0.0369		0.99988			Best 4 variable model
	-0.6319		4.79	0.0382*	Suspended Lead
	1.0099		22405.80	0.0001*	Total Iron
	0.0013		27.76	0.0001*	Flow
	-0.0052		24.13	0.0001*	Total Suspended Solids
-0.0608		0.9999			Best 5 variable model
	0.0030		7.53	0.0113*	Antecedent Dry Days
	-2.9003		7.78	0.0102*	Suspended Copper
	1.0198		22266.52	0.0001*	Total Iron
	0.0015		37.62	0.0001*	Flow
	-0.0061		40.78	0.0001*	Total Suspended Solids
-0.0521		0.9999			Best 6 variable model
	0.0031		8.10	0.0092*	Antecedent Dry Days
	-2.2491		3.77	0.0645*	Suspended Copper
	-0.3987		1.50	0.2330	Suspended Zinc
	1.0229		20028.83	0.0001*	Total Iron
	0.0015		35.71	0.0001*	Flow
	-0.0067		40.98	0.0001*	Total Suspended Solids
-0.0543		0.9999			Best 7 variable model
	0.0029		6.82	0.0159*	Antecedent Dry Days
	-1.9941		2.62	0.1194	Suspended Copper
	-0.2212		0.46	0.5041	Suspended Lead
	-0.2967		0.67	0.4213	Suspended Zinc
	1.0189		11683.77	0.0001	Total Iron
	0.0014		34.97	0.0001	Flow
	-0.0060		18.20	0.0003	Total Suspended Solids
-0.0573		0.9999			Best 8 variable model
	0.0032		5.30	0.0317*	Antecedent Dry Days
	-1.8961		2.17	0.1556	Suspended Copper
	-0.2896		0.56	0.4616	Suspended Lead
	-0.3318		0.75	0.3961	Suspended Zinc
	1.0210		8138.58	0.0001*	Total Iron
	0.0014		25.54	0.0001*	Flow
	-0.0036		0.12	0.7312	Inorganic Suspended Solids
	-0.0039		0.40	0.5358	Total Suspended Solids

TABLE 11-4 (Continued)

Intercept "b"	Slope "m"	r^2	F-test		Parameters
			F	P	
SUSPENDED LEAD:					
-0.0021		0.9623			Best 1 variable model
	0.7518		715.40	0.0001*	Total Lead
-0.0042		0.9713			Best 2 variable model
	0.3591		8.41	0.0073*	Suspended Copper
	0.7366		831.82	0.0001*	Total Lead
-0.0060		0.9728			Best 3 variable model
	0.0002		1.51	0.2295	Antecedent Day Days
	0.3169		6.19	0.0196*	Suspended Copper
	0.7519		711.35	0.0001*	Total Lead
-0.0061		0.9732			Best 4 variable model
	0.0002		1.09	0.3061	Antecedent Dry Days
	0.2714		3.16	0.0879	Suspended Copper
	0.0254		0.31	0.5825	Suspended Zinc
	0.7512		690.05	0.0001*	Total Lead
-0.0029		0.9753			Best 5 variable model
	0.2501		2.58	0.1210	Antecedent Dry Days
	0.8089		316.32	0.0001*	Suspended Copper
	0.00003		0.39	0.5393	Suspendesd Zinc
	0.0021		2.86	0.1038	Total Lead
	-0.0014		3.09	0.0916	Total Suspended Solids
-0.0034		0.9754			Best 6 variable model
	0.2050		1.19	0.2861	Suspended Copper
	0.0212		0.20	0.6589	Suspended Zinc
	0.8060		297.77	0.0001*	Total Lead
	0.00003		0.49	0.4921	Flow
	0.0020		2.56	0.4236	Inorganic Suspended Solids
	-0.0014		2.71	0.1131	Total Suspended Solids
-0.0040		0.9760			Best 7 variable model
	0.2242		1.36	0.2562	Suspended Copper
	-0.0010		0.42	0.5219	Suspended Iron
	0.0398		0.51	0.4839	Suspended Zinc
	0.7989		270.65	0.0001*	Total Lead
	0.00003		0.50	0.4867	Flow

TABLE 11-4 (Continued)

Intercept "b"	Slope "m"	r^2	F-test F	F-test P	Parameters
	0.0024		2.91	0.1022	Inorganic Suspended Solids
	-0.0015		2.97	0.0991	Total Suspended Solids
-0.0037		0.9760			Best 8 variable model
	-0.00004		0.03	0.8689	Antecedent Dry Days
	0.2251		1.31	0.2656	Suspended Copper
	-0.0011		0.43	0.5178	Suspended Iron
	0.0423		0.51	0.4820	Suspended Zinc
	0.8003		252.60	0.0001*	Total Lead
	0.0025		0.51	0.4847	Flow
	-0.0016		2.20	0.1527	Inorganic Suspended Solids
			2.73	0.1503	Total Suspended Solids
SUSPENDED ZINC:					
0.0099		0.3312			Best 1 variable model
	1.9418		13.87	0.0009*	Suspended Copper
-0.0063		0.4252			Best 2 variable model
	1.9955		16.39	0.0004*	Suspended Copper
	0.1461		4.41	0.0451*	Total Zinc
0.0208		0.5071			One - 3 variable model
	1.3537		6.31	0.0185*	Suspended Copper
	0.0125		8.61	0.0069*	Suspended Iron
	-0.0028		9.27	0.0053*	Inorganic Suspended Solids
0.0208		0.51183			A second - 3 variable model
	0.0208		26.27	0.0001*	Suspended Iron
	0.3567		6.62	0.0161*	Suspended Lead
	-0.0045		23.90	0.0001*	Inorganic Suspended Solids
0.0269		0.5252			Best 3 variable model
	0.0296		27.72	0.0001*	Suspended Iron
	0.4781		10.49	0.0033*	Suspended Lead
	-0.0027		25.31	0.0001*	Total Suspended Solids

TABLE 11-4 (Continued)

Intercept	Slope	r^2	F-test		Parameters
"b"	"m"		F	P	
0.0238		0.5608			Best 4 variable model
	0.8385		2.02	0.1674	Suspended Copper
	0.0146		12.12	0.0019*	Suspended Iron
	0.3593		4.62	0.0415*	Suspended Lead
	-0.0022		12.99	0.0014*	Total Suspended Solids
0.6047		0.0055			Best 5 variable model
	1.1552		4.01	0.0566	Suspended Copper
	0.0137		7.86	0.0098*	Suspended Iron
	0.2863		3.83	0.0622	Suspended Lead
	0.1215		2.93	0.0998	Total Zinc
	-0.0032		9.94	0.0043*	Inorganic Suspended Solids
-0.0162		0.6169			Best 6 variable model
	0.0009		1.42	0.2460	Antecedent Dry Days
	1.4219		6.38	0.0188	Suspended Copper
	0.1452		8.39	0.0081*	Suspended Iron
	0.1751		4.29	0.0498*	Total Zinc
	-0.0113		6.67	0.0167*	Inorganic Suspended Solids
	0.0054		4.48	0.0454*	Total Suspended Solids
-0.0094		0.6279			Best 7 variable model
	0.0008		1.07	0.3131	Antecedent Dry Days
	1.1655		3.22	0.0867	Suspended Copper
	0.0151		8.75	0.0073*	Suspended Iron
	-0.0085		2.31	0.1427	Inorganic Suspended Solids
	0.0034		0.93	0.3447	Total Suspended Solids
	0.1703		0.65	0.4281	Suspended Lead
	0.1503		2.76	0.1111	Total Zinc
-0.0048		0.6317			Best 8 variable model
	0.0008		1.17	0.2912	Antecedsent Dry Days
	-0.0001		0.22	0.6466	Flow
	1.2520		3.32	0.0828	Suspended Copper
	0.0151		8.49	0.0083*	Suspended Iron
	0.1600		0.55	0.4669	Suspended Lead
	0.1238		1.30	0.2664	Total Zinc
	-0.0090		2.41	0.1354	Inorganic Suspended Solids
	0.0037		1.02	0.3239	Total Suspended Solids

TABLE 11-4 (Continued)

Intercept "b"	Slope "m"	r^2	F-test		Parameters
			F	P	
INORGANIC SUSPENDED SOLIDS:					
-1.3681		0.9893			Best 1 variable model
	0.6604		2590.01	0.0001*	Total Suspended Solids
-0.6895		0.9951			Best 2 variable model
	0.9498		32.12	0.0001*	Suspended Iron
	0.5306		465.86	0.0001*	Total Suspended Solids
-0.5199		0.9967			Best 3 variable model
	0.7030		20.20	0.0001*	Suspended Iron
	-23.7347		12.62	0.0015*	Suspended Lead
	0.5762		565.08	0.0001*	Total Suspended Solids
-1.3814		0.9976			Best 4 variable model
	0.0764		9.47	0.0050	Antecedent Dry Days
	0.5535		14.72	0.0008	Suspended Iron
	-22.9438		15.60	0.0006	Suspended Lead
	0.6057		685.86	0.0001*	Total Suspended Solids
-1.0007		0.9980			Best 5 variable model
	0.0765		10.90	0.0030*	Antecedent Dry Days
	-0.0102		4.73	0.0397*	Flow
	0.5191		14.68	0.0008*	Suspended Iron
	-20.2333		13.24	0.0013*	Suspended Lead
	0.6014		770.43	0.0001*	Total Suspended Solids
-0.8339		0.9981			Best 6 variable model
	0.0810		11.73	0.0023*	Antecedent Dry Days
	-0.0103		4.88	0.0375	Flow
	0.6396		12.11	0.0020*	Suspended Iron
	-16.7283		6.36	0.0190*	Suspended Lead
	-7.1375		0.94	0.3414	Suspended Zinc
	0.5838		427.40	0.0001*	Total Suspended Solids
-0.8082		0.9981			Best 7 variable model
	0.07601		10.06	0.0044*	Antecedent Dry Days
	-0.0129		6.15	0.0213*	Flow
	0.5632		8.30	0.0087*	Suspended Iron

TABLE 11-4 (Continued)

Intercept "b"	Slope "m"	r^2	F-test		Parameters
			F	P	
	28.6237		1.22	0.2809	Suspended Copper
	-19.0061		7.55	0.0117*	Suspended Lead
	-9.5354		1.56	0.2243*	Suspended Zinc
	0.5901		423.14	0.0001*	Total Suspended Solids
-5.2122		0.8145			1 variable model
	0.2395		123.10	0.0001*	Specific Conductance
	37.4639		29.28	0.0001*	Total Phosphorus
2.5428		0.9191			Best - 1 variable model
	4.2067		317.98	0.0001*	Total Iron
-5.4662		0.9110			One - 2 variable model
	0.1776		86.84	0.0001*	Specific Conductance
	37.4639		29.28	0.0001*	Total Phosphorus
1.1418		0.9352			Best - 2 variable model
	4.0922		347.61	0.0001*	Total Iron
	49.0434		6.71	0.0157	Total Lead
-0.9370		0.9472			One - 3 variable model
	157.6895		5.91	0.0222*	Total Copper
	3.2406		64.25	0.0001*	Total Iron
	51.9202		8.85	0.0063	Total Lead
-1.1143		0.9673			Best 3 variable model
	0.1294		74.47	0.0001*	Specific Conductivity
	-78.3333		72.75	0.0001*	Total Organic Carbon
	.5570		121.36	0.0001*	Total Phosphorus
0.8712		0.9507			One - 4 variable model
	174.1952		7.16	0.0130	Total Copper
	3.2637		66.97	0.0001*	Total Iron
	43.4518		5.61	0.0259*	Total Lead
	-17.5058		1.77	0.1956	Total Zinc
-2.0722		0.9743			Best 4 variable model
	0.1209		76.95	0.0001*	Specific Conductance
	-55.5462		21.18	0.0001*	Ammonia
	0.4419		48.16	0.0001*	Total Organic Carbon
	14.7941		6.77	0.0153*	Total Phosphorus

TABLE 11-4 (Continued)

Intercept	Slope	r^2	F-test		Parameters
"b"	"m"		F	P	
-3.4033		0.9781			Best 5 variable model
	0.1282		90.79	0.0001*	Specific Conductance
	-64.7385		28.09	0.0001*	Ammonia
	0.4939		57.57	0.0001*	Total Organic Carbon
	12.0968		4.82	0.0381*	Total Phosphorus
	0.0338		4.21	0.0513	Flow
-4.7276		0.9806			Best 6 variable model
	0.1115		47.48	0.0001*	Specific Conductance
	-84.9701		26.09	0.0001*	Ammonia
	0.6128		43.12	0.0001*	Total Organic Carbon
	12.5953		5.63	0.0264*	Total Phosphorus
	0.2111		2.93	0.0993	Antecedent Dry Days
	0.0426		6.55	0.0175*	Flow
-5.4807		0.9815			Best 7 variable model
	0.1238		38.53	0.0001*	Specific Conductance
	-88.6159		27.32	0.0001*	Ammonia
	0.6521		42.25	0.0001*	Total Organic Carbon
	-0.8099		1.11	0.3040	Total Nitrogen
	13.0159		6.01	0.0227*	Total Phosphorus
	0.2817		4.06	0.0562	Antecedent Dry Days
	0.0571		7.01	0.0147*	Flow
-5.3783		0.9816			Best 8 variable model
	0.1307		19.74	0.0002*	Specific Conductance
	-86.0057		20.29	0.0002*	Ammonia
	-1.0353		0.11	0.7491	Nitrite/Nitrate
	0.6395		34.06	0.0001*	Total Organic Carbon
	-0.8291		1.11	0.3046	Total Nitrogen
	12.9781		5.73	0.0261*	Total Phosphorus
	0.2814		3.89	0.0619	Antecedent Dry Days
	0.0574		6.78	0.0166*	Flow
-5.6746		0.9817			Best 9 variable model
	0.1347		14.67	0.0010*	Specific Conductance
	-82.0607		9.58	0.0057*	Ammonia
	-1.0542		0.10	0.7505	Nitrite/Nitrate
	0.6224		20.87	0.0002*	Total Organic Carbon
	-0.9600		0.92	0.3494	Total Nitrogen
	20.5553		0.05	0.8281	Total Dissolved Phosphorus
	12.3604		3.95	0.0608	Total Phosphorus
	0.2530		1.68	0.2090	Antecedent Dry Days
	0.0598		5.70	0.0269*	Flow

TABLE 11-4 (Continued)

Intercept	Slope	r^2	F-test		Parameters
"b"	"m"		F	P	
TOTAL SUSPENDED SOLIDS:					
-4.9723		0.7542			One - 1 Variable Model
	0.3471		85.95	0.0001*	Specific Conductance
-6.6145		0.8780			A second - 1 variable model
	6.1928		201.60	0.0001*	Total Iron
2.1986		0.9893			Best 1 variable model
	1.4981		2590.01	0.0001*	Inorganic Suspended Solids
-5.4235		0.8883			One - 2 variable model
	66.5246		32.38	0.0001*	Total Phosphorus
	0.2371		54.31	0.0001*	Specific Conductance
2.7118		0.9207			A second - 2 variable model
	120.1860		14.52	0.0007*	Total Lead
	5.9123		261.46	0.0001*	Total Iron
1.2625		0.9944			Best 2 variable model
	56.0410		25.01	0.0001*	Suspended lead
	1.4633		4158.44	0.0001*	Inorganic Suspended Solids
-3.3932		0.9324			One - 3 variable model
	60.7857		42.09	0.0001*	Total Phosphorus
	0.2787		16.98	0.0003*	Total Organic Carbon
	0.1508		20.90	0.0001*	Specific Conductance
-0.6527		0.9345			A second - 3 variable model
	255.2116		5.51	0.0268*	Total Copper
	124.8420		18.20	0.0002*	Total Lead
	4.5341		44.75	0.0001*	Total Iron
2.1623		0.9578			A third - 3 variable model
	-143.2127		82.86	0.0001*	Ammonia
	0.9685		124.97	0.0001*	Total Organic Carbon
	0.1629		41.33	0.0001*	Specific Conductance

TABLE 11-4 (Continued)

Intercept "b"	Slope "m"	r^2	F-test		Parameters
			F	P	
2.9050		0.9965			Best 3 variable model
	-0.1611		15.31	0.0006*	Antecedent Dry Days
	46.9804		25.24	0.0001*	Suspended Lead
	1.4431		5735.49	0.0001*	Inorganic Suspended Solids
3.7712		0.9436			One - 4 variable model
	295.5934		7.97		Total Copper
	104.1237		12.46	0.0017*	Total Lead
	4.5904		51.23	0.0001*	Total Iron
			4.09	0.0539	Total Zinc
-2.3280		0.9737			A second 4 variable model
	0.1007		15.13	0.0007*	Flow
	-158.2346		142.85	0.0001*	Ammonia
	1.0611		207.38	0.0001*	Total Organic Carbon
	0.1801		74.46	0.0001*	Specific Conductance
2.4799		0.9972			Best 4 variable model
	-0.1374		12.74	0.0015	Antecedent Dry Days
	40.6416		21.17	0.0001*	Suspended Lead
	-0.6737		6.60	0.0166*	Suspended Iron
	1.5929		685.86	0.0001*	Inorganic Suspended Solids
-2.9216		0.9780			One - 5 variable model
	0.0879		12.46	0.0017*	Flow
	-128.5917		48.47	0.0001*	Ammonia
	18.0025		4.67	0.0409*	Total Phosphorus
	0.9090		85.30	0.0001*	Total Organic Carbon
	0.1676		67.87	0.0001*	Specific Conductance
1.8742		0.9976			Best 5 variable model
	-0.1367		14.21	0.0010*	Antecedent Dry Days
	0.0157		4.18	0.0521	Flow
	36.2764		17.83	0.0003*	Suspended Lead
	-0.6621		7.18	0.0131*	Suspended Iron
	1.6127		770.43	0.0001*	Inorganic Suspended Solids

TABLE 11-4 (Continued)

Intercept "b"	Slope "m"	r^2	F-test		Parameters
			F	P	
-5.3559		0.9817			One - 6 variable model
	0.3881		4.65	0.0418*	Antecedent Dry Days
	0.1042		18.23	0.0003*	Flow
	-165.7859		46.27	0.0001*	Ammonia
	18.9189		5.92	0.0232*	Total Phosphorus
	1.1275		68.03	0.0001*	Total Organic Carbon
	0.1369		33.36	0.0001*	Specific Conductance
1.8786		0.998			Best 6 variable model
	-0.1229		10.57	0.0035*	Antecedent Dry Days
	0.0196		5.55	0.0273*	Flow
	41.1098		18.89	0.0002*	Suspended Lead
	-46.8903		1.39	0.2509	Suspended Copper
	-0.4648		2.45	0.1312	Suspended Iron
	1.5820		626.04	0.0001*	Inorganic Suspended Solids
-9.1453		0.9832			One - 7 variable model
	0.1456		18.00	0.0003*	Flow
	+110.4300		35.43	0.0001*	Ammonia
	-2.5692		3.54	0.0732	Total Nitrogen
	252.6337		6.90	0.0154	Total Dissolved Phosphorus
	11.5458		2.09	0.1625	Total Phosphorus
	0.8986		100.19	0.0001*	Total Organic Carbon
	0.2090		41.95	0.0001*	Specific Conductance
1.7195		0.9978			Best 7 variable model
	-0.1282		10.70	0.0035*	Antecedent Dry Days
	0.0208		5.80	0.0248*	Flow
	38.5831		13.83	0.0012*	Suspended Lead
	-55.0845		1.69	0.2068	Suspended Copper
	-0.5878		2.70	0.1146	Suspended Iron
	8.2123		0.40	0.5316	Suspended Zinc
	1.6106		423.14	0.0001*	Inorganic Suspended Solids

TABLE 11-4 (Continued)

Intercept	Slope	r^2	F-test		Parameters
"b"	"m"		F	P	
-9.0002		0.9841			Best 8 variable model
	0.2847		1.14	0.2983	Antecedent Dry Days
	0.1478		18.61	0.0003*	Flow
	-141.2586		16.95	0.0005*	Ammonia
	-2.4179		3.12	0.0918	Total Nitrogen
	162.3006		1.61	0.2185	Total Dissolved Phosphorus
	14.7675		3.01	0.0976	Total Phosphorus
	1.0623		35.76	0.0001	Total Organic Carbon
	0.1886		25.46	0.0001	Specific Conductance
-9.0309		0.9841			Best 9 variable model
	0.2852		1.09	0.3097	Antecedent Dry Days
	0.1477		17.66	0.0004*	Flow
	-142.1877		14.59	0.0011*	Ammonia
	0.3488		0.01	0.9402	Nitrite/Nitrate
	-2.4098		2.94	0.1021	Total Nitrogen
	162.0387		1.53	0.2308	Total Dissolved Phosphorus
	14.7881		2.87	0.1058	Total Phosphorus
	1.0668		31.11	0.0001*	Total Organic Carbon
	0.1863		14.23	0.0012*	Specific Conductance

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